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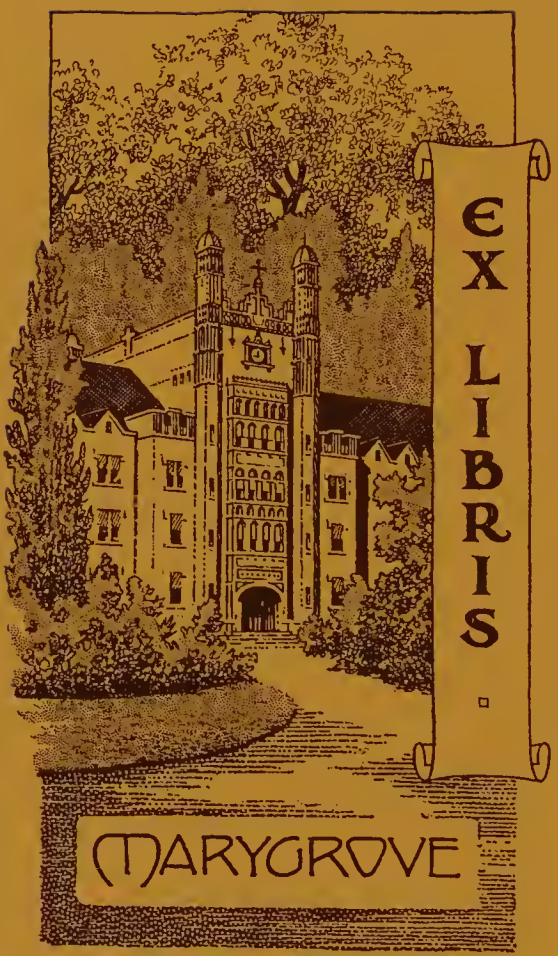
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DETERMINATION OF THE INTERRELATIONS, PARTIAL AND MULTIPLE, BETWEEN VARIOUS ANTHROPOMETRIC MEASUREMENTS OF COLLEGE WOMEN

By

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PART ONE

VALIDITY OF MEASURES AND SELECTION OF DATA

CHAPTER I

INTRODUCTION

The Awakened Interest in Health and the Beginnings of Objective Measurement in This Field

The Height-Weight-Age Tables. One of the most outstanding movements in contemporary society is the increasing interest in the health of the individual. Even prior to the World War there was an awakening consciousness of the value of research in health, but it was the high tension of the great European struggle and incidents attendant thereon that quickened and stimulated it. Tables using weight in relation to height and age as an index of health have taken, for obvious and conventional reasons, a prominent place in the minds of many individuals. "Emerson is perhaps the staunchest advocate of the relation of weight to height as a means of determining nutrition. His procedure with a group of children is to weigh and measure them, compute the percentage deviation from the average weight for height, and then classify them as follows:

I. 7% or more below average weight for height—malnourished
II. Under average but less than 7%—borderline
III. Average to 20% above—normal (about 10% above is considered ideal)
IV. 20% or more above average—overweight."[1]

Though Emerson recognizes other signs of malnutrition, "his faith in the weight-height index is sufficient, indeed, to allow him to state: 'The basis of weight for height has proved to be an accurate measure of the condition of undernourished children, and in the many thousands of cases that have come under my observation I have never found an instance in which it has proved to be impracticable.' "[2]

The official sanction accorded these tables by Emerson and

[1] Roberts, Lydia J., *Nutrition Work with Children*, p. 27.
[2] *Ibid.*, p. 28.

others[3] has impressed the popular mind with a deep respect, amounting almost to veneration in fact, for what seems to be so definite a standard of personal health. This common error is excusable, however, when we consider that these tables have been a pioneer step in the direction of objective health measurement, and that their influence on many individuals has been salutary in guidance toward attempts at attainment of the "normal" weight (which in reality was the average weight) for their age and height, through proper exercise, diet, and a host of other ways.

Dissatisfaction with the Current Use of Height-Weight-Age Tables. For some time this rather wholesale grouping of persons has been felt to be inadequate and erroneous. The most serious consequence of systematic dependence upon these height-weight-age tables is that no real consideration has been given to the different kinds of body build; individuals of both heavy and light framework are all expected to have the same "normal" weight. Baldwin expresses dissatisfaction with the widespread abuse of the tables of children's weight (compiled by Dr. Thomas D. Wood and himself) for deciding individual normal weight. He believes that "the chief difficulty has been and will continue to be to know what weight is normal for individual children. . . ."[4] After giving some of the mean deviations of the average variability for a certain number of inches of height, he says, "these limits are not magic lines which differentiate well and sick children; they simply indicate how the majority of children in fairly good health cluster around a central tendency or average for each inch in height at different chronological ages."[5]

Taylor, however, in a prior article, attacked the idea with greater vehemence. "There is just one delusion that is held on

[3] "The weight of a child is a practical index of his physical condition. If he is habitually seven per cent or more underweight for height, he is considered by many prominent pediatricians to be a child seriously in need of attention. . . ." Grant, Mrs. Ernest R., "The Child, The Scales, and The Tape Measure," *The Outlook*, 1922, Vol. 131, p. 67.

"Clinical experience has led us to the conclusion that children who are chronically seven per cent or more underweight may be considered ill children." Dr. David Mitchell of N. Y. Bureau of Educational Experts (quoted in article by Mrs. Grant, above).

[4] Baldwin, Bird T., "The Use and Abuse of Height-Weight Tables as Indices of Health and Nutrition," *Journal of the American Medical Association*, 1924, Vol. 82, p. 4.

[5] *Ibid.*, p. 4.

to and almost worshipped by an overwhelming majority . . . that any particular individual . . . should weigh a certain number of pounds."[6] He puts into words a need gradually beginning to be felt by many workers in the field of health. "Many child welfare workers do not go as far as they should. Noticing the weight . . . was a first step. It has served a purpose. . . . But it does not go nearly as far as it should. . . . It cannot be depended upon. It is not accurate."[7] His chief plea here is for a thorough physical and medical examination for every child.

Recognition of Different Kinds of Body Build and the Offering of New Weight Tables Attempting to Consider These Differences. Taylor argues that "by emphasizing attention to slender children almost exclusively, we are neglecting the great mass of children who may be more heavily framed. . . . Underweight does not mean a certain percentage below the general average weight for the same age and height . . . for this does not allow for individual differences in body build."[8] He tells us that Dr. R. Tait McKenzie of the University of Pennsylvania, an authority on anthropology, has confirmed his findings as to the "wide variation of normal types of build from slender to stocky" and says that in children in good health "there is a physical development proportional to the type of build."[9]

Taylor's argument for using the obviously different types of body build as more correct bases for proper weight determination than the generally accepted height-weight tables, seems to have sounded a new note in the field of measurement in health. He classifies[10] children as slender, slender-medium, medium, medium-heavy, and heavy, and insists that an individual can be properly compared only with those of "his own type of build." For these five types he has prepared weight tables, based on height and girth of shoulders, chest, right and left upper arms, waist, hips, thighs, and calves, thus attempting to devise a plan in accord with his idea that tables should take into account the wide variations in type of build.

[6] Taylor, Charles K., "The Great Underweight Delusion," *The Outlook*, 1922, Vol. 130, p. 423.

[7] Taylor, Charles K., "More Enlightenment Wanted," *The Outlook*, 1922, Vol. 131, p. 68.

[8] *Ibid.*, p. 69.

[9] *Ibid.*, p. 69.

[10] Taylor, Charles K., "The Great Underweight Delusion," *op. cit.*, p. 425.

Recent approval on the segregation of persons into types for the purpose of determining weight has been given by Miss Agnes Wayman, head of the Department of Physical Education at Barnard College, Columbia University. She feels that the tables for adults "while accurate as far as they go, do not go quite far enough, for they do not take into consideration an individual's type of structure, or heredity, which is very important. Two individuals may be of the same age and height, but one stocky and broad in structure, the other, slender and with small bones. Should their weight be identical? Obviously not."[11]

Miss Wayman offers as a substitute three tables prepared by Miss Katherine Sibley, head of the Department of Physical Education for Women at Syracuse University. These tables make the division of individuals into slender, medium, and stocky on the basis of the breadth of shoulders.[12]

Indices of Body Build, Determined by Using Stature and Weight—and Stature, Weight, and Age. The constantly increasing interest in diversity of types of variation in the human body, and the increasing use of scientific method have resulted in various attempts at classification of body build. In contradistinction to the methods suggested above, of using body build in the determination of weight, we observe another interesting method of attack that reverses the process and classifies body build into types from a consideration of weight and stature. Davenport says that "it is highly desirable to determine the law of relation of height to weight for the period of development from birth on."[13] He has been supported by no less an authority than Bardeen, who declares that this method of Davenport's expresses "relative build much more definitely than through use of such terms as slender or stocky."[14] Bardeen has supplemented Davenport's work with a method of his own and has devised a method of obtaining the "index of build" of an individual through data on stature, weight, and age.[15]

[11] Wayman, Agnes R., *Education Through Physical Education*, 2nd Edition, p. 94.

[12] *Ibid.*, pp. 95, 98.

[13] Davenport, Charles Benedict, "Height-Weight Index of Build," *American Journal of Physical Anthropology*, 1920, Vol. III, No. 2, p. 471.

[14] Bardeen, C. R., "The Height-Weight Index of Build in Relation to Linear and Volumetric Proportions and Surface Area of the Body During Post-Natal Development." (Author's review of *Contributions to Embryology*, No. 46, Publication 272, Carnegie Institution of Washington, 1919, pp. 483-554) *American Journal of Physical Anthropology*, Vol. III, No. 2, p. 264. [15] *Ibid.*, p. 264.

Davenport[16] has divided adult build into five classes—very slender, slender, medium, medium fleshy, and very fleshy. Using weight, stature, and the hypothesis that "the chest girth in persons of the same build varies very closely or exactly with stature," he has reported the range of indices of his five standard classes of build.

The Use of Indices in the Determination of Normal Weight. Dissatisfaction with the inadequacy of tables of weight and height and desire for a more satisfactory method of determining physical fitness of the individual have resulted in the calculation of a number of indices for weight determination. Dreyer declares that "most of the existing tables dealing with the size of the normal human body are based on the theory that definite relations between age, height and weight exist,"[17] and that "it has been satisfactorily proved that such relationships do not exist when individuals varying widely in size are examined."[18] He feels strongly against the use of age as a necessary factor in these calculations—"no reference is made to the age of the individual because for the range of indices given, it has been found that the question of age is of little or no importance up to an age of about fifty years."[19]

To ascertain if the weight of an individual is normal, he gives the following two formulæ[20] for weight (for females) and says that the average of the two figures obtained therefrom is "the normal weight corresponding to the observed length of the trunk and the circumference of the chest."[21]

$$\text{Weight of the body in grammes} = 0.36093 \sqrt[0.313]{\text{length of trunk in centimeters}}$$

$$\text{Weight of the body in grammes} = 0.30213 \sqrt[0.284]{\text{cir. of chest in centimeters}}$$

Another method of determining body weight has been arrived at by Gray and Parmenter, who have experimented considerably

[16] Davenport, Charles Benedict, *Body Build and Its Inheritance*, Carnegie Institution of Washington, 1923. Publication No. 329, Paper No. 35 of the Department of Genetics, pp. 26-27.

[17] Dreyer, Georges and Hanson, G. F., *The Assessment of Physical Fitness By Correlations of Vital Capacity and Certain Measurements of the Body*, p. 1.

[18] *Ibid.*, p. 2.

[19] *Ibid.*, p. 5.

[20] *Ibid.*, p. 3.

[21] *Ibid.*, p. 12.

with measures of chest depth, chest width, and shoulder width, and have come to the conclusion that, as an index of body weight, chest depth is the best of these three.[22] They have used for measurement 100 candidates for the Harvard varsity football team, from 18 to 20 years of age, who were organically sound and better than the average in physique. Using zero order correlations, they have found that in this group depth and width tend to vary inversely, that neither shoulder width nor chest width seems to have any bearing on weight determination, but that chest depth does exhibit a considerable correlation with body weight. Their conclusion is, then, that "chest depth may be a real accessory to the height in predicting what a man ought to weigh."[23]

In an interesting study, Miss Marion Johnson[24] has developed three methods of weight prediction for women of college age, i.e., "Chest-Volume," "Chest-Volume times Height," and "Chest-Volume times Height^2." On the basis of zero order correlations of these indices with weight, she finds that the index of "Chest Volume times Height" gives the best prediction of these three. She has attempted to recognize a nutritional factor by restricting one group of her subjects to those who were judged as being in good nutrition by two examiners, one of whom was a physician.[25]

Another Method of Weight Determination. One of the most recent investigations on the determination of body weight is that made by J. A. Highsmith and Dorthea Sorenson.[26] Correlations made (zero order) indicate that pelvic breadth is an important determinant for weight prediction in women of college age. This study of Highsmith and Sorenson makes some

[22] Gray, Horace and Parmenter, D. C., "Chest Depth as an Index of Body Weight," *Journal of the American Medical Association*, 1923, Vol. 81, No. 26, p. 2183.

[23] *Ibid.*

[24] Johnson, Marion March, *A Study of the Relation of Certain Skeletal Dimensions to Body Weight in 1030 Women of College Age*, p. 71. Master's thesis at Wellesley College, Wellesley, Mass., June 1924.

[25] Dr. Raymond Franzen, however, through direct correlation of opinions (on the same individuals) of medical experts in the field of nutrition, has recently found that as regards children at least, there is likely to be considerable divergence of opinion between any two specialists in judging condition of nutrition. Even experts often use quite diverse weighting of elements in judging an individual's nutritional status. (Franzen, Raymond, *Physical Measures of Growth and Nutrition*, School Health Research Monographs, No. 2, 1929. American Child Health Association, 370 Seventh Avenue, New York City.) Hence we may be permitted to question Miss Johnson's nutritional groupings.

[26] Highsmith, J. A. and Sorenson, Dorthea, "A Tentative Weight-Prediction Formula." *American Physical Education Review*, September, 1928, Vol. XXXIII, No. 7, p. 448.

use of the regression equation in weight prediction, but the inclusion of more skeletal dimensions would have made this study even more valuable.

Dr. Raymond Franzen, Research Director, School Health Study, American Child Health Association (under whose guidance it has been the writer's privilege to make this study), has recently completed the most extensive investigation ever made on weight determination in children.[27] He uses a battery of eleven anthropometric measurements. Some comparisons of results obtained on the groups used in his study will be made later with those obtained on an older group used by the writer.

The Use of a Health Zone. There is a comparatively recent trend among users of height-weight-age tables toward the devising of a "health zone," allowing a leeway of a certain percentage above or below the average or so-called standard weight, for determining what would be regarded as undesirable deviations from a norm of individual health. Dr. Emmett Holt[28] says that "not all healthy children are of the same height or weight for a given age or even of the same weight for a given height . . . the *average* is not the *normal*; the average is a line, the normal is a zone," and he recognizes a range of variation in the normal zone of "less than ten per cent below or twenty per cent above the average weight for the height." He guards himself by adding, "this standard is somewhat arbitrary, but in practice it serves well."

Dreyer[29] says, "It is only when the meaning of 'the normal' with respect to these measurements (weight, trunk length, chest circumference, and vital capacity) is understood, and when the limits of the normal have been properly defined that it will be possible to study with any degree of accuracy or success the deviations from the normal, and to give a definite significance to such terms as 'good physique,' 'poor physique,' 'physical fitness,' and so forth." According to Dreyer, body weight is classified as normal, possibly abnormal, probably abnormal, and certainly abnormal,[30] and he places individual weight in one of the following classes according to its deviation from the normal weight

[27] Franzen, Raymond, *op. cit.*

[28] Holt, Dr. Emmett, "Child Weighing Not a Fad," *The Outlook*, 1922. Vol. 131, p. 248.

[29] Dreyer, Georges and Hanson, G. F., *op. cit.*, p. 3. [30] *Ibid.*, 14–15.

obtained through the use of his formulæ:

as much as 5% above or below "normal"—possibly abnormal
as much as 10% above or below "normal"—probably abnormal
as much as 15% above or below "normal"—certainly abnormal

Wood and Rowell point out the confusion resulting from the use of "underweight," "normal," and "overweight." They are dissatisfied with the current use of these terms and believe that they should not be considered synonymous with any terms meaning state of health or nutrition.[31]

They propose several new terms: "normal range" or "health weight," a range between "under health weight" and "over health weight." "Under health weight" is considered as weight from 7% to 10% below the table weight, and "over health weight" as 15% above table weight in high school pupils and 20% above table weight in elementary school pupils and younger children.

These authors have presented a rather new and interesting point of view on the subject of type, and give a rather scathing criticism on some of the type classifications. "There have been various attempts to estimate and interpret the weight index of health according to types of physique. One objection to this is that with an increase or a decrease of weight, the individual may pass from one type of physique to another. It is increasingly apparent to the best scientific investigators, that any accurate and dependent classification *must* be based on *skeletal measurements. No satisfactory skeletal measurements for this purpose have been yet demonstrated.*[32] Therefore, in the opinion of the authors, such standards of weight based on classification of physique are neither scientific nor satisfactory."[33]

A Preliminary Study

The beginnings of this study were undertaken in an attempt to discover a better basis for weight determination in women of college age, to discover what combinations of anthropometric dimensions might be found useful for determination of weight.

[31] Wood, Thomas D. and Rowell, Hugh Grant, *Health Supervision and Medical Inspection of Schools*, p. 88.

[32] This book was published two years prior to the American Child Health Association Research Monograph, *Physical Measures of Growth and Nutrition*, which has made extensive use of skeletal measurements.

[33] Wood, Thomas D. and Rowell, Hugh Grant, *op. cit.*, p. 88.

From measurements of a group of sixty-eight cases, physical education students at Teachers College, Columbia University (on which a number of rank correlations had been made), there was undertaken a preliminary study of a small age-group (twenty-five cases), to discover better what relationship, if any, might exist between weight and the several skeletal measurements, and to select from these results, those measurements seeming to suggest possibilities for further study. The skeletal measurements used were, besides height, those of sitting height, width of shoulders, depth of chest, width of chest, and width of hips. Age was also used as a possible salient factor.

The Final Form of This Study

Through a consideration of results obtained in the preliminary study, this problem has broadened itself from its original single objective into a several-fold problem which may be stated as follows:
An attempt—

(1) To discover which, if any, anthropometric combinations have diagnostic value for determining weight expectancy in college women.
(2) To find bases for construction of tables to facilitate such diagnoses as are found valuable in this study.
(3) To develop relations implicit in combinations of skeletal measurements themselves.

Intercorrelations[34] of age, weight, and the skeletal measurements were made (Pearson product-moment method). The correlations were as follows:

TABLE 1

Correlation of Weight with Age and Each of Six Skeletal Dimensions

$r_{\text{weight-chest depth}}$	.69
$r_{\text{weight-width of hips}}$	.64
$r_{\text{weight-chest width}}$	.56
$r_{\text{weight-sitting height (to top of head)}}$	.44
$r_{\text{weight-shoulder width}}$	.37
$r_{\text{weight-height}}$	.34
$r_{\text{weight-age}}$	− .32

[34] See Table A in the Appendix for the 28 correlations.

While these results seemed to point rather significantly to a different basis for weight prediction, nevertheless the small number of cases used prohibited any definite decisions. A much larger and more random sampling and not a specialized group, as these were, would be necessary upon which to base decisions with any degree of accuracy.

CHAPTER II

SOURCE OF DATA, OBJECTIVITY OF EXAMINERS, AND SELECTION OF DATA FOR FURTHER INVESTIGATION

Source of Data for Further Investigation

It was found possible to obtain measurements at Wellesley College, and since, by inspection of data at this college, it was seen that Wellesley draws its student population from all over the United States, this seemed a fairly representative group of American college women upon which to base conclusions. In addition, a certain degree of satisfactory condition of health is assured of each entering student by the college regulation that each student is "required to have a medical examination including urinalysis before entering college, and to present a medical statement of good health at the time of matriculation."[1]

Records were obtained for 815 students, all of whose measurements were taken by either one of two examiners. This group of 815 represents the number remaining after the exclusion of all incomplete records of measurements and those records in which obvious errors had been made by recorders. The meas urements of Oriental students were also omitted because of possible racial dissimilarities of body build.

Some indication of racial dissimilarities of body build between Oriental and American women seems to be brought out in a recent study made on the basal metabolism of Orientals[2] (nine students). Their sitting height seems to be relatively smaller than that of American students and it is possible that their other measurements may also have different relationships. It was therefore decided best to exclude all records of Orientals from the calculations.

[1] Johnson, Marion March, *op. cit.*, p. 1.

[2] MacLeod, Grace, Crafts, Elizabeth, and Benedict, Francis, "The Basal Metabolism of Orientals." Reprint from the *American Journal of Physiology*, Vol. LXXVIII, No. 2, July, 1925, p. 453.

The Methods of Making the Measurements

Wellesley measurements used in this study are as follows:

weight
age
standing height
sitting height—to top of head
sitting height—to 7th cervical vertebra
depth of chest
width of chest
width of shoulders
width of hips

Abbreviations used in this study for these measures are:

weight	wt.
age	age
standing height	ht.
sitting height (to top of head)	sit. ht. (t.h.)
sitting height (to 7th cervical vertebra)	sit. ht. (7 c.v.)
depth of chest	ch.d.
breadth of chest	ch.w.
width of shoulders	biac.
width of hips	iliac

The methods of making these measurements were as follows:

Weight[3]

"Measured by means of a Chatillo platform spring balance, the subject wearing a light muslin robe. The needle was permitted to come to complete rest and the result recorded in kilograms to the nearest quarter."

Age

Recorded in years and months.

Standing Height[3]

"Measured with the subject standing on the platform, as tall as possible, back against the upright, and looking straight ahead. The spring slide was lowered until it rested firmly on the top of the head."

Sitting Height[3]

"Secured after the manner of Dreyer with the subject seated upon the platform, knees bent and the soles of the feet resting

upon the platform. She was instructed to sit as tall as possible and by resting the hands against the floor of the platform to gently push herself backward until the back of the sacrum was in contact with the upright. In this position the weight rests mainly upon the ischial tuberosities with a slight padding of muscular tissue, thus giving a measurement closely approximating an actual bony dimension. Sitting height was made according to Dreyer's instruction."

Sitting Height[3]

"Measured to the spinous process of the *seventh cervical vertebra* in precisely the same way, with the exception of the fact that the measurement was read at the level of the spinous process of the seventh cervical vertebra, by means of a sliding T square with a sliding bar attached to the horizontal arm."

Depth of Chest[3]

"Taken as the antero-posterior distance midsternum at the level of the junction of the third rib with the sternum with spring calipers. The latter were placed upon the individual and the reading made at the end of normal expiration."

Width of Chest[3]

"The transverse horizontal distance at the level of the sixth rib midaxillary, a point about 5 centimeters below the axilla, was also made at the end of normal expiration. Sliding wooden calipers equipped with a special spring so that the tension was always the same and which obviated the necessity for the adjustment of pressure by the examiner were used."

Width of Shoulders

Taken from above the subject and measured to the outer edges of the acromion processes of the scapulæ.

Width of Hips

Measured as the transverse horizontal distance at the outer edges of the iliac crests at the widest point.

[3] "The metric system was used and readings were made to one-tenth of a centimeter or kilogram. All instruments were calibrated." Johnson, Marion March, *op. cit.*, pp. 40-41.

Objectivity of Examiners

In Table 2 are given in parallel columns (to two places only[4]) the 36 zero order r's[5] from highest to lowest, of group C[6] (390 cases) measured by two examiners and of group D[7] (425 cases) measured by one examiner only (who was one of the two examiners of group C). By inspection of the data it is apparent that the same correlations which were high when only one examiner was used were also high when two examiners were used.

It is equally apparent that the same correlations which were low when there was only one examiner were correspondingly low when there were two examiners. The presumption is, therefore, that as regards these two groups the personality of the examiner has nothing to do with the results obtained.

Sampling of Data

The differences between the correlations of similar variables in the two groups presented being in most cases extremely small, it appears that the group samplings are adequate and comparable. If the groups were not comparable, or the samplings inadequate or not sufficiently random, more and greater differences than these would appear.

If, therefore, the zero r's of the two groups are similar, the partial and multiple correlations computed from the two groups would be similar also, and it follows then that there is legitimate justification for throwing these two groups (C and D) into one group, thus having a larger and perhaps still more reliable

[4] All r's are computed to 5 places and recorded to four in order that no accumulation of errors might occur in the computation of partial and multiple correlations on account of the dropping of decimals. It is merely for the reader's convenience and for simplicity of comparison that the r's are listed here to two places only.

[5] Omission of the P. E. of r has been made for the following reason:

"$\text{P.E.}_r = \frac{.6745\,(1 - r^2)}{\sqrt{N}}$ This is the sampling error of r and does not involve errors of measurement, recording and interfering uncontrolled variables. Two r's of .70 each with an N of 1000 may have entirely different chance of being other than .70 in another group of 1000 under the same conditions as far as it is under the examiner's control. This is because the variables have entirely different errors of measurement. We believe that P. E. r has been interpreted by readers to mean the chances that the r will diverge in data gathered in the same way. We wish to avoid such a misinterpretation on the part of our readers. Sampling errors of r must be negligible if the N is adequate."—Franzen, Raymond, *op. cit.*

[6] See Table C in the Appendix for the 36 r's to 4 decimal places.

[7] See Table D in the Appendix for the 36 r's to 4 decimal places.

TABLE 2

COMPARISON OF CORRELATIONS OF TWO GROUPS IN ORDER TO PROVE RANDOM SAMPLING AND OBJECTIVITY OF EXAMINERS

	Group C	*Group D*
$r$sit.ht. 7c.v.-sit.ht.t.h.	.91	.90
$r$ht.-sit.ht.t.h.	.78	.76
$r$ht.-sit.ht.7c.v.	.74	.69
$r$wt.ch.w.	.64	.61
$r$wt.-iliac	.63	.58
$r$wt.-ch.d.	.63	.62
$r$biac.-ch.w.	.55	.52
$r$wt.-biac.	.50	.46
$r$ch.w.-iliac	.48	.49
$r$wt.-ht.	.45	.47
$r$biac.-iliac	.44	.34
$r$wt.-sit.ht.t.h.	.43	.34
$r$wt.-sit.ht.7 c.v.	.39	.32
$r$iliac-ch.d.	.38	.37
$r$ch.w.-ch.d.	.36	.32
$r$ht.-iliac	.34	.37
$r$ht.-biac.	.30	.32
$r$biac.-sit.ht.t.h.	.29	.26
$r$iliac-sit.ht.t.h.	.29	.26
$r$sit.ht.7c.v.-iliac	.25	.26
$r$ch.w.-sit.ht.t.h.	.23	.24
$r$ht.-ch.w.	.23	.33
$r$biac.-ch.d.	.23	.20
$r$sit.ht.-biac.	.22	.25
$r$ch.d.-sit.ht.t.h.	.21	.08
$r$ht.-ch.d.	.20	.22
$r$sit.ht.7c.v.-ch.w.	.19	.19
$r$sit.ht.7c.v.-ch.d.	.16	.08
$r$age-sit.ht.t.h.	.04	.007
$r$age-iliac	.03	.08
$r$age-ch.d.	.003	.03
$r$age-wt.	−.002	.09
$r$age-sit.ht.7c.v.	−.03	.04
$r$age-ht.	−.04	.04
$r$age-biac.	−.04	.09
$r$age-ch.w.	−.05	.03

group on which to base conclusions. This is what has been done; the partials, multiples, Betas[8] of regression, and final conclusions drawn in this study being based on this composite group of 815

[8] "Beta" is used here as the coefficient of standard scores in the multiple regression equation. Kelley, T. L., *Statistical Method*, pp. 280 ff.

cases. Table E in the Appendix presents the intercorrelations for this combined group, Table H the partials, and Table I the multiples.

Elimination of Data

In rather striking contrast to the apparent sameness of coefficients of correlation of the above two groups are presented the zero order *r*'s of another group—group B, 429 cases—compared with the zero *r*'s of this composite group of 815 cases. This group of 429[9] was selected in the same manner and from the same college as the previous two groups, the only "selection" for any of the cases being that each group was a separate college class.[10] As regards the taking of the measurements, however, in the examinations of this group, instead of all being made by one or two persons, as were groups C and D, the students were distributed among six different examiners for measurement. Inspection of the two sets of zero *r*'s shows some marked differences, especially in some of the *r*'s involving biacromial width.

These differences were so marked that a reinspection of original data was made, and it was discovered that at least one examiner of the 429 was undoubtedly liable to error in measuring biacromial width. Using a random 100 cases (group Z) whose measurements were taken by two of the examiners of group B (other than the examiners of group E), correlations of biacromial width with weight, height, and chest width were made. These correlations show decided differences from the corresponding correlations of group E. In this group these correlations were .38, .16, and .37, while the corresponding correlations in group E were .49, .32, and .54. Apparently at least one of these two examiners was liable to error in measuring biacromial width, using some other point instead of the acromion process for measurement.

Comparison of the means of the various skeletal measurements in the groups of 429, 390, 425, and 815 cases indicates that the mean biacromial width of the 429 shows a far greater difference from the mean biacromial of any other group than does any other mean biacromial, and in addition, this difference is the

[9] See Table B in the Appendix for *r*'s of this group to 4 decimal places.

[10] As noted above, cases showing evident recording errors, and cases of Oriental students were omitted.

TABLE 3

COMPARISON OF CORRELATIONS OF TWO GROUPS IN ORDER TO JUSTIFY STATISTICAL ELIMINATION OF ONE GROUP BECAUSE OF NON-OBJECTIVITY OF EXAMINERS

	Group E 815 Cases	*Group B 429 Cases*
$r_{ht.\text{-}sit.ht.7c.v.}$	.72*	.56
$r_{wt.\text{-}ch.w.}$	.63	.55
$r_{wt.\text{-}iliac}$	.61	.62
$r_{wt.\text{-}ch.d.}$	.63	.57
$r_{biac.\text{-}ch.w.}$	.54	.25
$r_{wt.\text{-}biac.}$	.49	.29
$r_{ch.w.\text{-}iliac.}$	.49	.48
$r_{wt.\text{-}ht.}$	.46	.55
$r_{biac.\text{-}iliac}$	.38	.31
$r_{wt.\text{-}sit.ht.7c.v.}$	.36*	.32
$r_{iliac\text{-}ch.d.}$	.38	.35
$r_{ch.w.\text{-}ch.d.}$	.38	.22
$r_{ht.\text{-}iliac}$	.35	.36
$r_{ht.\text{-}biac.}$	.32	.13
$r_{sit.ht.7c.v.\text{-}iliac}$	.26*	.18
$r_{ht.\text{-}ch.w.}$	.29	.33
$r_{biac.\text{-}ch.d.}$	.23	.24
$r_{sit.ht.7c.v.\text{-}biac.}$	.24*	.12
$r_{ht.\text{-}ch.d.}$	.22	.25
$r_{sit.ht.7c.v.\text{-}ch.w.}$	.19*	.16
$r_{sit.ht.7c.v.\text{-}ch.d.}$	.12*	.14
$r_{age\text{-}iliac}$	.09	.0001
$r_{age\text{-}ch.d.}$	.15	.09
$r_{age\text{-}wt.}$	.10	.03
$r_{age\text{-}sit.ht.7c.v.}$	.01*	.−05
$r_{age\text{-}ht.}$	.04	.−06
$r_{age\text{-}biac.}$	.08	.08
$r_{age\text{-}ch.w.}$	.10	.07

* These figures are not the r's of the 815 cases taken as one group, since no r of any measure of sitting height was computed for this group. These figures represent merely an average of the corresponding r's of groups C and D.

greatest difference between any pair of corresponding means of the skeletal measurements. (The means of the skeletal measures found in the different groups are given on page 18.)

From a consideration of these results, it was decided to omit these 429 cases in the compilation of a larger group on which to draw final conclusions, and groups C and D were used instead to make up the larger group.

	Group B *429 Cases*	*Group C* *390 Cases*	*Group D* *425 Cases*	*Group E* *815 Cases*	*Group Z* *100 Cases*
ht.	163.62	163.67	162.78	163.20	163.69
sit. ht. 7 c.v.	60.79	61.51	61.03	———	———
biac.	32.68	36.22	35.82	36.01	33.30
ch. w.	24.55	24.38	23.80	24.08	24.23
iliac.	27.54	27.11	26.84	26.97	———
ch. d.	15.55	17.15	16.38	16.75	———
sit. ht. t.h.	———	85.67	85.19	———	———

Any vital conclusions reached are apparent in the tables of both R and R^2 [11] and partials and Betas of regression computed from the data of the 815 group. It is interesting to note that the same general conclusions hold true with the 429 as with the 815 cases, even though there is an apparent error in the measurement of at least one of the variables of the 429 cases.

Comparison of the Two Groups, Showing Apparent Compensation Between Two Skeletal Dimensions. Partials, multiples, and Betas of regression computed on this group of 429 cases (which was the first large group worked with) show that this error in biacromial measurement seems to cause a curious apparently compensatory shifting in some relative values of importance to weight. When this error causes the Beta[12] on acromial width to become almost zero, this same error apparently causes the partials and Beta on height to increase proportionately.[13] To show briefly the seeming effect of this error in measuring biacromial width on the height partials, there are listed below in parallel columns the fourth order partials of weight and the skeletal measures of both groups—the 815 and the 429 cases.

[11] R^2 is used instead of R because "using correlations between zero order standard scores and residual standard scores we may show that:

$$R_{1.234}{}^2 = r^2{}_{12} + r_{1(3.2)}{}^2 + r_{1(4.23)}{}^2$$

It may also be shown that:

$$R_{1.234}{}^2 - R_{1.23}{}^2 = r_{1(4.23)}{}^2$$"—Franzen, Raymond, *op. cit.*

Proof of these formulæ and further expansion of them are to be published in the near future.

[12] The coefficient of standard score in the multiple regression equation, Kelley, T. L., *op. cit.*

[13] There seems to be an apparent composite weighting of height and acromial width values. Height and acromial width together seem to exert a certain proportionate amount in the Betas, and this composite seems to hold rather constant. When an error in the taking of one of them distorts its Beta (as in group B—429 cases), the Beta of the other is correspondingly distorted in the opposite direction so that the combined Beta values of the two result in practically the same amount even though one of these two skeletal dimensions, as in this case, has evidently been incorrectly measured.

TABLE 4

COMPARISON OF TWO GROUPS: ONE OBJECTIVELY MEASURED, AND THE OTHER NOT OBJECTIVELY MEASURED, IN THEIR 4TH ORDER PARTIALS OF FIVE SKELETAL CHARACTERISTICS WITH WEIGHT SHOWING APPARENT COMPENSATION IN THE HEIGHT-SHOULDER RELATIONSHIP

	Group E *815 Cases*	*Group B* *429 Cases*
$r_{wt.\text{-iliac (all other factors constant)}}$	.32	.36
$r_{wt.\text{-ht. (all other factors constant)}}$	.29	.41
$r_{wt.\text{-ch.d. (all other factors constant)}}$	.51	.48
$r_{wt.\text{-biac. (all other factors constant)}}$	.16	.04
$r_{wt.\text{-ch.w. (all other factors constant)}}$	.34	.33

To show how this error affects the Betas of regression, the coefficients of standard scores in the multiple regression equation on weight of the two groups are as follows:

	Group E *815 Cases*	*Group B* *429 Cases*
Height	.188	.284
Iliac width	.233	.279
Chest depth	.372	.346
Biacromial width	.109	.021
Chest width	.267	.237
	1.169	1.167

Reducing these to per cents, we have:

	Group E *815 Cases*	*Group B* *429 Cases*
Height	16%	25%
Iliac width	20	24
Chest depth	32	29
Biacromial width	9	2
Chest width	23	20
	100%	100%

The reader interested in further comparison of these two groups is referred to all the zero r's and first, second, third, and fourth order partials to the fourth decimal of both groups, and to both tables of multiples (and multiples squared) of the several variables with weight.

Statistical Justification of Non-Elimination of Cases. There was some question of doubt as to whether one case in group C and one case in group D should be included in the correlations as they seemed possible cases of extreme error of measurement on account of being unusually large in their several dimensions; for this reason, two sets of correlations were made for each of these groups,[14] one including and one omitting the questionable case, to see if the value of r would be shifted consistently up or down. The zero r's of weight with each of the skeletal measurements are shown below. The shifting value of r is not consistently either way, some r's being lower and some higher when the case of supposed error is out. In both groups it is seen that the differences in r's with the case out were practically negligible. Therefore, it appears that there is no statistical justification for the exclusion of the cases (it cannot be proved statistically that there is error in measurement), and they were accordingly included in the compilation of the larger group of 815 cases on which conclusions were based.

TABLE 5

STATISTICAL JUSTIFICATION FOR NON-ELIMINATION OF CERTAIN DOUBTFUL CASES

	Group C Case In	*Group C 2 Case Out*	*Group D Case In*	*Group D 2 Case Out*
$r_{wt.\text{-}age}$	− .002	− .02	.09	.09
$r_{wt.\text{-}ht.}$	.45	.47	.47	.47
$r_{wt.\text{-}sit.ht.\ 7\ c.v.}$	.39	.41	.32	.32
$r_{wt.\text{-}biac.}$	.50	.51	.46	.45
$r_{wt.\text{-}ch.w.}$	.64	.64	.61	.60
$r_{wt.\text{-}iliac}$	.63	.62	.58	.51
$r_{wt.\text{-}ch.d.}$	.63	.62	.62	.58
$r_{wt.\text{-}sit.ht.\ t.h.}$	.43	.45	.34	.35

Elimination of Sitting Height Measurements. It has been noted that both measures of sitting height were omitted from the calculation of the r's of group E (815 cases) on which conclusions were based. Inspection of the zero r's of the two groups of which it is composed shows that the correlation of weight and full height is greater than correlation of weight and either of the sitting height measures. In addition, the correlation of

[14] See Tables C, D, C 2, and D 2 in Appendix.

either measure of sitting height with height is so high relatively, and the correlation of either measure of sitting height with weight is so low relatively, that the addition of either measure of sitting height to a multiple correlation already involving height would make no addition to the multiple.

TABLE 6

CORRELATIONS OF SITTING HEIGHT WITH WEIGHT JUSTIFYING THE ELIMINATION OF BOTH MEASURES OF SITTING HEIGHT FOR USE IN THIS STUDY

	Group C	*Group D*
$r_{wt.\text{-}ht.}$	.45	.47
$r_{wt.\text{-}sit.ht.\ (7\ c.v.)}$	.39	.32
$r_{wt.\text{-}sit.ht.\ (t.h.)}$	.43	.34
$r_{ht.\text{-}sit.ht.\ (7\ c.v.)}$	.74	.69
$r_{ht.\text{-}sit.ht.\ (t.h.)}$	.78	.76
$r_{sit.ht.\ (7\ c.v.)\text{-}wt.\ (with\ ht.\ constant)}$	.10	.14
$r_{sit.ht.\ (t.h.)\text{-}wt.\ (with\ ht.\ constant)}$	.00	− .04

In both groups partial correlations of either measure of sitting height with weight, irrespective of full height, are so small that it appears that height includes practically all of the value that could be obtained from the additional use of sitting height. Therefore for the zero and partial correlations of group E full height was used, as this measure of height is a better determinant for weight than either of the other two.

Elimination of the Age Factor. Although the factor of age was used in computing the group of zero *r*'s of group E (815 cases), age was omitted from the computation of the partials on this group. A casual inspection of the *r*'s with age will show that in this late adolescent period the age factor seems to have

TABLE 7

CORRELATIONS OF AGE WITH WEIGHT AND SEVEN SKELETAL MEASUREMENTS, JUSTIFYING THE ELIMINATION OF THE AGE FACTOR FROM USE IN THIS STUDY

	Age with							
Group	*wt.*	*ht.*	*sit.ht. (7 c.v.)*	*biac.*	*ch.w.*	*iliac*	*ch.d.*	*sit.ht. (t.h.)*
C (390 cases)	− .002	− .04	− .03	− .04	− .05	.03	.003	.04
D (425 cases)	.09	.04	.04	.09	.03	.08	.03	.007
E (815 cases)	.10	.04	—	.08	.10	.09	.15	—

practically no influence on any of the skeletal measurements (except perhaps, very slightly, on chest measurements).

While in this larger (and therefore probably more reliable) group—group E (815 cases)—the *r*'s are positive, most of them are practically zero. Therefore, the age variable was not included in the partials.

CHAPTER III

METHOD OF TREATMENT OF THE WELLESLEY DATA

The method of treatment of the Wellesley data of the group of 815 students was as follows:

(1) The computation of all possible correlations of zero order (Pearson Product Moment method) of weight and the several skeletal measurements.

Note: Exceptions—the two measures of sitting height, as previously noted.

(2) The computation of all first, second, third, and fourth order partials of weight with the five skeletal measurements.

(3) The computation of all first, second, and third order partials of the five skeletal measurements themselves.

(4) The computation of the multiple correlation of weight with the five skeletal measurements, checked by the computation of the multiple in five different ways.

(5) The computation of all the multiples of weight with every possible combination of the five skeletal dimensions.

(6) Table made showing:

(*a*) the relative value of weight prediction by using the various skeletal combinations; the degree of accuracy to which weight can be predicted from each single measure and from each combination of measures.

(*b*) the amount of variations in weight due to factors unknown.

(7) Tables made showing increase in multiples of the variables with weight, starting each table with one of the five skeletal factors, then building up each table by adding cumulatively every remaining factor to every combination, thus showing the increased reliability of prediction in each resulting situation.

(8) The computation of the Betas of regression on weight,

using the variables height, depth of chest, width of chest, width of shoulders, and width of hips. These Betas show the proportionate influence on variations in weight (of the amount of weight that can be predicted) of each of these five skeletal dimensions.

(9) A regression equation on weight built up using all five skeletal measures as predictive factors.

(10) The construction of symmetry formulæ, regression equations for determining the expectancy of each of the five skeletal dimensions from the known values of the other four.

PART TWO

RESULTS AND SUMMARY

CHAPTER I

THE INADEQUACY OF HEIGHT-WEIGHT TABLES AND THE RELATIVE IMPORTANCE OF OTHER FACTORS THAN HEIGHT IN WEIGHT DETERMINATION

The Case Against Height as a Reliable Predictive Factor for Weight

Tables 8 and 9 in this chapter, Table H in the Appendix, and other tables already referred to present the correlations[1] on which the multiples, and other calculations, and all discussions in this study are based. The last figure in each of the following two tables represents the multiple correlations of all five skeletal dimensions with weight—"the relation existing when we have the best possible weighting of each of the component parts."[2]

TABLE 8

Correlation of Weight with Each of the Five Skeletal Dimensions

Height	.46
Biacromial width	.49
Width of chest	.63
Width of hips	.61
Depth of chest	.63
Multiple correlation with weight	*.8286*

These figures show clearly that the skeletal measure of height is decidedly inadequate as a determinant for predicting weight. In these zero order r's height presents a correlation with weight of .46, the lowest correlation with weight of the five skeletal measures experimented with. Chest depth, chest width, and hip width show correlations with weight respectively of .63, .63, and

[1] On 815 cases (taken from Table E, Appendix).

[2] Franzen, Raymond, *op. cit.*

.61, indicating that chest and hip dimensions play a more important part than height in determination of weight.[3]

TABLE 9

CORRELATIONS OF WEIGHT WITH EACH OF THE FIVE SKELETAL DIMENSIONS, HOLDING ALL OTHER FOUR DIMENSIONS CONSTANT

Height	.29
Biacromial width	.16
Width of chest	.34
Width of hips	.32
Depth of chest	.51
Multiple correlation with weight	*.8286*

With all other skeletal factors constant, the argument against height as a predictive basis for weight is seen still more clearly. Height now has a correlation with weight of only .29, while hip and chest dimensions continue to preserve a higher relationship with weight than does height. The multiple R adequately supports this argument, for, by a comparison of the multiple correlation of all five factors with weight with the five fourth-order multiples[4] where one factor is omitted, it can be seen that the increase in the multiple R made by height is next to the lowest in amount of all five variables.

TABLE 10-A

MULTIPLE CORRELATION OF THE FIVE SKELETAL DIMENSIONS WITH WEIGHT, AND THE SIMILAR MULTIPLE OF ANY FOUR OF THEM, SHOWING THE RELATIVE WORTH OF THE MULTIPLE WHEN OMITTING ANY VARIABLE

R of weight and all five skeletal variables	.8286
R (omitting the shoulder width variable)	.8238
R (omitting the height variable)	.8105
R (omitting the hip width variable)	.8062
R (omitting the chest width variable)	.8028
R (omitting the chest depth variable)	.7584

To compare more directly the amount each factor adds we must translate these values to R^2. [5]Table 10 then becomes:

[3] This will be seen more clearly in the discussion of the multiple R's.

[4] See table of increasing R and R^2, Table I in Appendix.

[5] "The squares of the correlations are used since the value of the correlations is in direct proportion to their squares and the comparisons are then adequate."—Franzen, Raymond, *op. cit.* (Also see footnote, p. 18.)

TABLE 10-B

R^2 of weight and all five skeletal variables	.6866
R^2 (omitting the shoulder width variable)	.6786
R^2 (omitting the height variable)	.6569
R^2 (omitting the hip width variable)	.6500
R^2 (omitting the chest width variable)	.6445
R^2 (omitting the chest depth variable)	.5752

From the above tabulation we discover that the variables add of themselves the following comparable amounts in their R^2's.

The shoulder width variable adds	.0080
The height variable adds	.0297
The hip width variable adds	.0366
The chest width variable adds	.0421
The chest depth variable adds	.1114

In either form of Table 10 we can easily see that omitting the measurement of height has less influence on the value of prediction than omitting the measurement of chest or hip dimension, that chest depth adds of itself more than twice as much as its nearest competitor, chest width, and more than three times as much as height.

The Skeletal Determinants of Weight

Table 11 gives the Beta coefficients of five skeletal measurements which produce the combination yielding the highest multiple correlation with weight. When all measures are reduced to comparable units by the method of standard scores, then the coefficients of these comparable scores in the regression equation represent the relative emphasis each carries in the optimum correlation with weight.

TABLE 11

Relative Force of Five Skeletal Dimensions* Giving the Best Prediction of Weight

Height	.19
Width of hips	.23
Depth of chest	.37
Width of shoulders	.11
Width of chest	.27
Multiple correlation with weight	*.8286*

* Coefficients of standard scores in the multiple regression equation.

CHART I.* PROPORTIONAL INFLUENCE ON WEIGHT OF FIVE SKELETAL DIMENSIONS

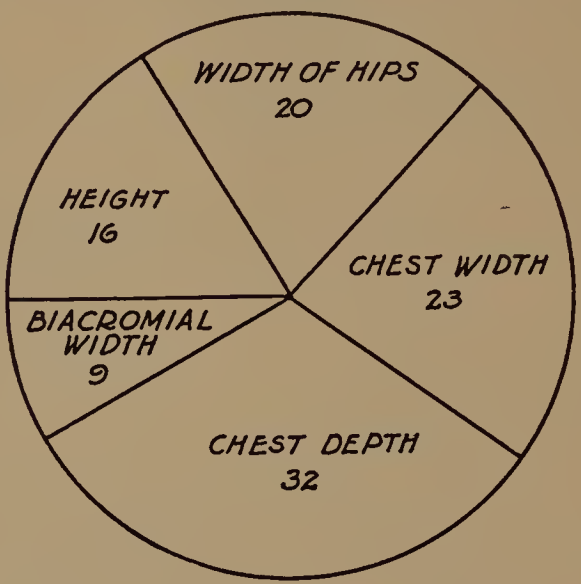


Chart I presents graphically the same facts as given in Table 11 (see also p. 41), the figures being reduced to per cents in order to make the diagram possible. In reading this chart it must be remembered that these are the relative amounts of emphasis exerted by each factor.

Again it is seen that height is a less important factor than chest and hip dimensions as regards influence on variations in weight. Shoulder width has even less influence. Its influence on weight is small and even this influence is shared by height.

THE IMPORTANCE OF CHEST DEPTH AS A PREDICTIVE FACTOR AND THE RELATIVE INFLUENCE ON WEIGHT OF THE VARIOUS SKELETAL COMBINATIONS

Of all the measurements used, chest depth was found to be more closely associated with weight than any of the others. Shoulder width appeared to be the least important predictive factor associated with weight, and height next least in importance. If, therefore, we can take only one measurement to predict weight, it would be far better to take chest depth than height, or in fact any other measurement, and if only two, then the two chest

* In the construction of Chart I the material is treated in the same manner as similar material is treated by the American Child Health Association Division of Research. See Franzen, *op. cit.*

measurements of depth and breadth.[6] The two chest measurements are responsible for more than one-half of the variation in weight that can be predicted from bony framework. This is also true of the combination of chest depth with hip width—although to a slightly less extent.

Chart II presents graphically the multiple correlations of weight with all possible combinations of the five skeletal dimensions used. A short explanation of some parts of this chart will enable the reader to comprehend readily the several meanings it gives in graphic form. Each line represents the predictive value of one measure or a combination of measures.[7]. For example, the third line represents the predictive value of the combination of height and shoulder dimensions, and the sixth line from the bottom represents the predictive value of the hip and the two chest dimensions. The top line represents the factor with the lowest predictive value, and the bottom line, the combination with the highest predictive value in multiple correlation. The bottom line represents the predictive value of the combination of the five skeletal measures (height, biacromial width, depth of chest, width of chest, and width of hips) to weight. The value of this bottom line is a multiple correlation of .83.

The twenty-first line represents the predictive value of the two chest dimensions to weight. This combination of the two chest dimensions is .76, while the highest single combination of height with any skeletal factor is .71, the combination of height and chest depth; and this combination of .71 is the lowest of all the single combinations which chest depth has with any skeletal factor. All the lowest single combinations are those of height or shoulders with another factor, and they range downward from .71 (height and chest depth, as already stated) to .59, the multiple resulting from a combination of height and shoulder width.

On the basis of two factors only, therefore, the least important combination of skeletal measurements for weight prediction is shown to be height and shoulder width, while the most important pair of factors is chest depth and chest width. In fact, chest

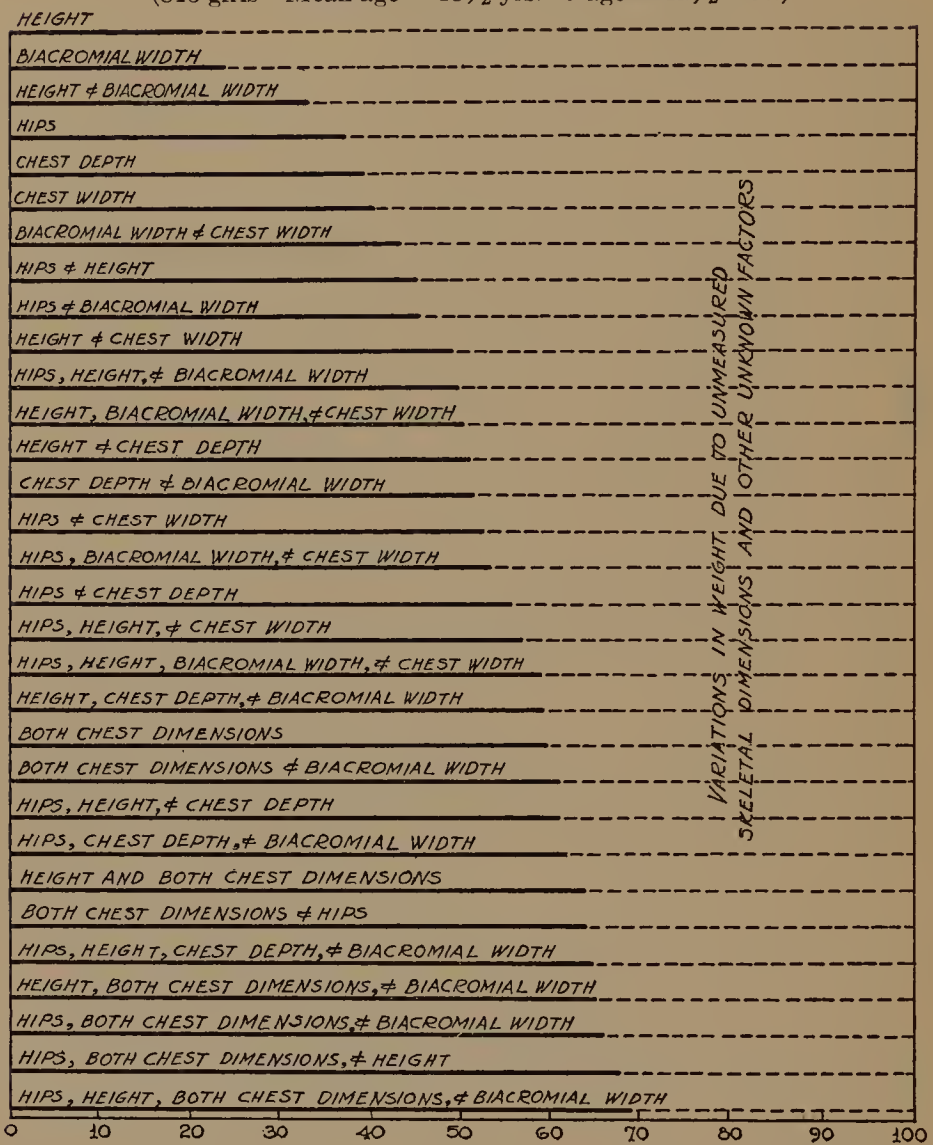
[6] This will be seen still more clearly in further discussion of the multiple R's.

[7] These lines are graphic representations of the several values of R^2. See Table I in Appendix.

CHART II*

RELATIVE VALUE OF WEIGHT PREDICTIONS USING VARIOUS COMBINATIONS OF SKELETAL DIMENSIONS (VALUES IN TERMS OF R^2)

(815 girls—Mean age = 18½ yrs. σ age = 12½ mos.)



depth and chest width form a combination more valuable by far than the combination of height with any other skeletal measurement.

* In the construction of Chart II the material is treated in the same manner as similar material is treated by the American Child Health Association Division of Research. See Franzen, *op. cit.*

It has been shown that both Betas of regression and multiples indicate that, of the skeletal measurements used, the two chest dimensions of depth and width have the greatest influence in weight prediction. Chest development, therefore, especially chest depth, has by late adolescent age[8] become the most important determinant of weight. If, therefore, a girl is underweight for her chest dimensions, but not for height, there is more reason to expect malnutrition than if she is underweight for her height, because underweight for height may mean having small chest dimensions.

The Height-Shoulder Relationship

As shown by the increase in multiples, height and shoulder width seem to have something in common, for an increase in one seems to accompany an increase in the other. Shoulder width and height add more nearly the same amount consistently to any combination predicting weight than does any other pair of factors. Shoulder width adds least to any multiple combination that contains height, and height adds least to any multiple combination that contains shoulder width.

For example, in Table 12, the hip width predictive value to weight is .37. When height is added, the predictive value becomes .45; adding chest depth, it becomes .56; adding shoulder width it becomes .45; adding chest width it becomes .52. In this group it happens that height and shoulder width seem to add, not only nearly, but almost exactly, the same.[9]

In Table 13, when the predictive value of height is .21, adding in turn hip width, chest depth, shoulder width, and chest width, we get as results .45, .51, .34, and .49, respectively. Here shoulder width adds the least, as it only raises the original figure of .21 to .34, while the addition of each of the others results in a higher figure.

Starting with chest depth (Table 14) height and shoulder width raise the predictive value to .51 and .52, respectively. These are both lower than .56 and .58, the values resulting from the addition of hip width and chest width.

[8] See later discussion of comparison of this group with a younger group, Chap. II, p. 40ff.

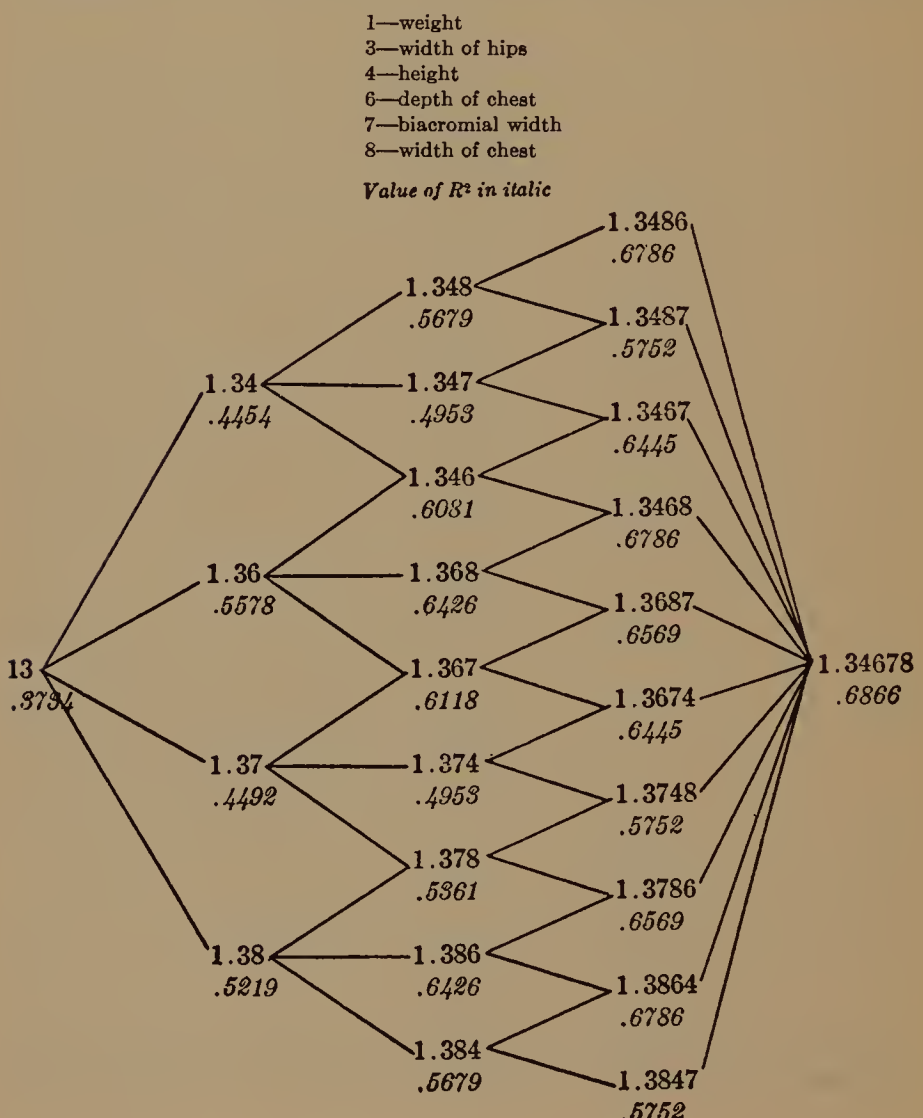
[9] Tables 12, 13, 14, 15, and 16 are a duplication of the graphic data in Chart II, but are arranged in this manner for the purpose of presenting a clearer picture of this discussion.

Starting with shoulder width (Table 15) we see that .34, the result from adding height to the shoulder prediction, is lower than .45, .52, or .43, the results from adding hip width, chest depth, and chest width, respectively.

Starting with chest width (Table 16) .49 and .43, the respective results from adding height and shoulder width, are both

TABLE 12

ALL OF THE MULTIPLE CORRELATIONS (SQUARED) WITH WEIGHT WHEN WIDTH OF HIPS IS ONE OF THE FACTORS, IN 815 GIRLS WHOSE MEAN AGE IS 18 YEARS 6 MONTHS.



less than .52 and .58, the results from adding hip width and chest depth.

Similarly, using each higher order of multiple presents this same type of relationship. Therefore, height and shoulder width are overlapping factors in their influence on weight.

Of all the skeletal dimensions used, shoulder width is more

TABLE 13

ALL OF THE MULTIPLE CORRELATIONS (SQUARED) WITH WEIGHT WHEN HEIGHT IS ONE OF THE FACTORS, IN 815 GIRLS WHOSE MEAN AGE IS 18 YEARS 6 MONTHS.

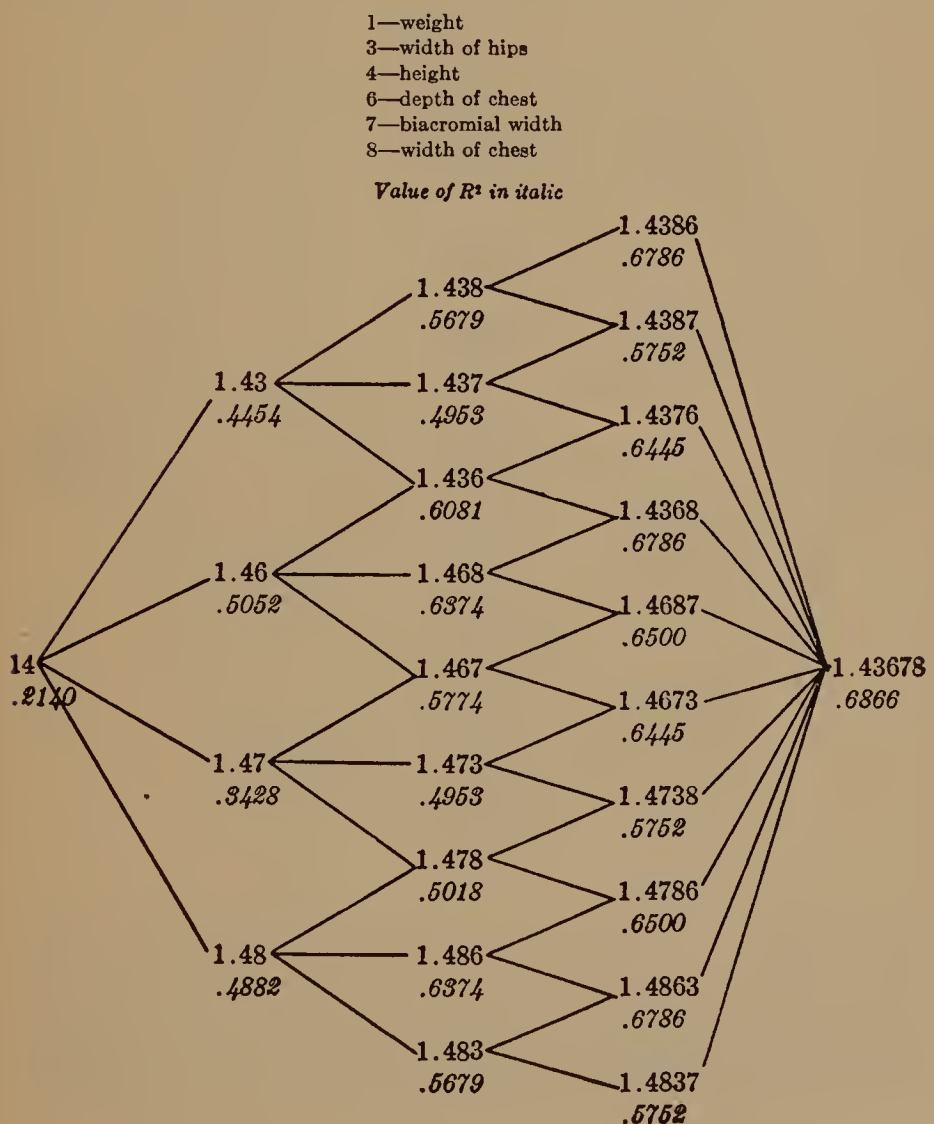
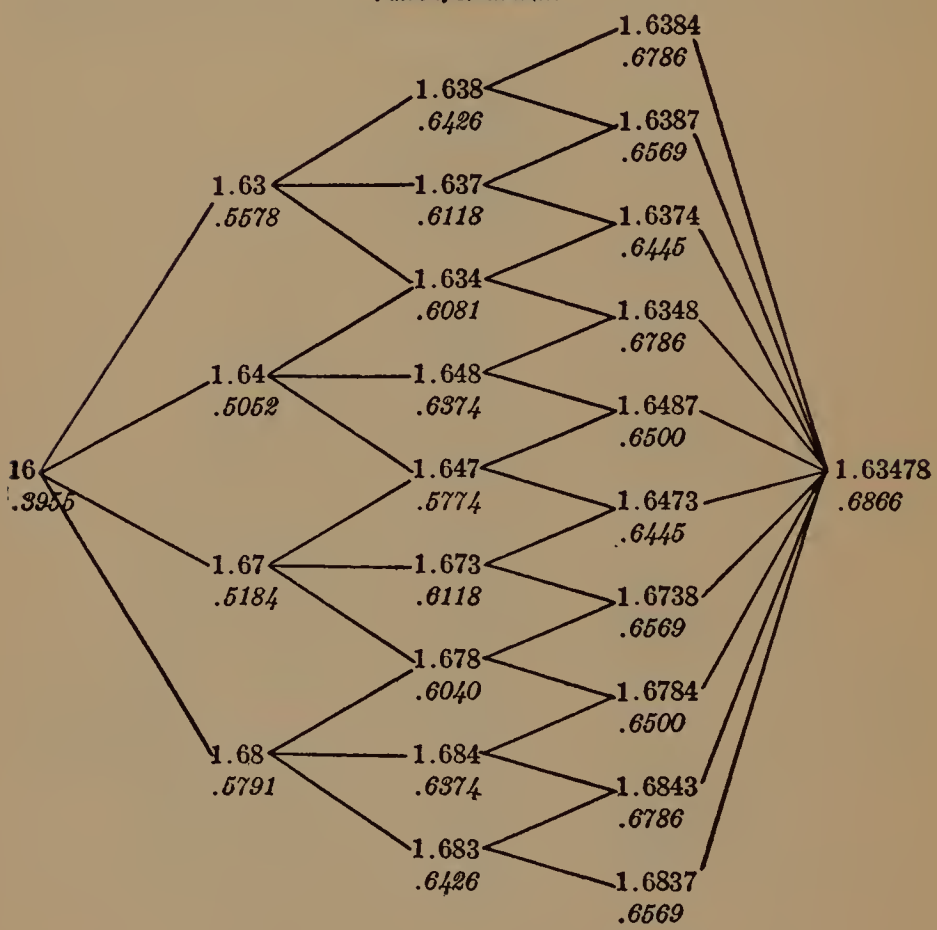


TABLE 14

ALL OF THE MULTIPLE CORRELATIONS (SQUARED) WITH WEIGHT WHEN DEPTH OF CHEST IS ONE OF THE FACTORS, IN 815 GIRLS WHOSE MEAN AGE IS 18 YEARS 6 MONTHS.

1—weight
3—width of hips
4—height
6—depth of chest
7—biacromial width
8—width of chest

Value of R^2 in italic



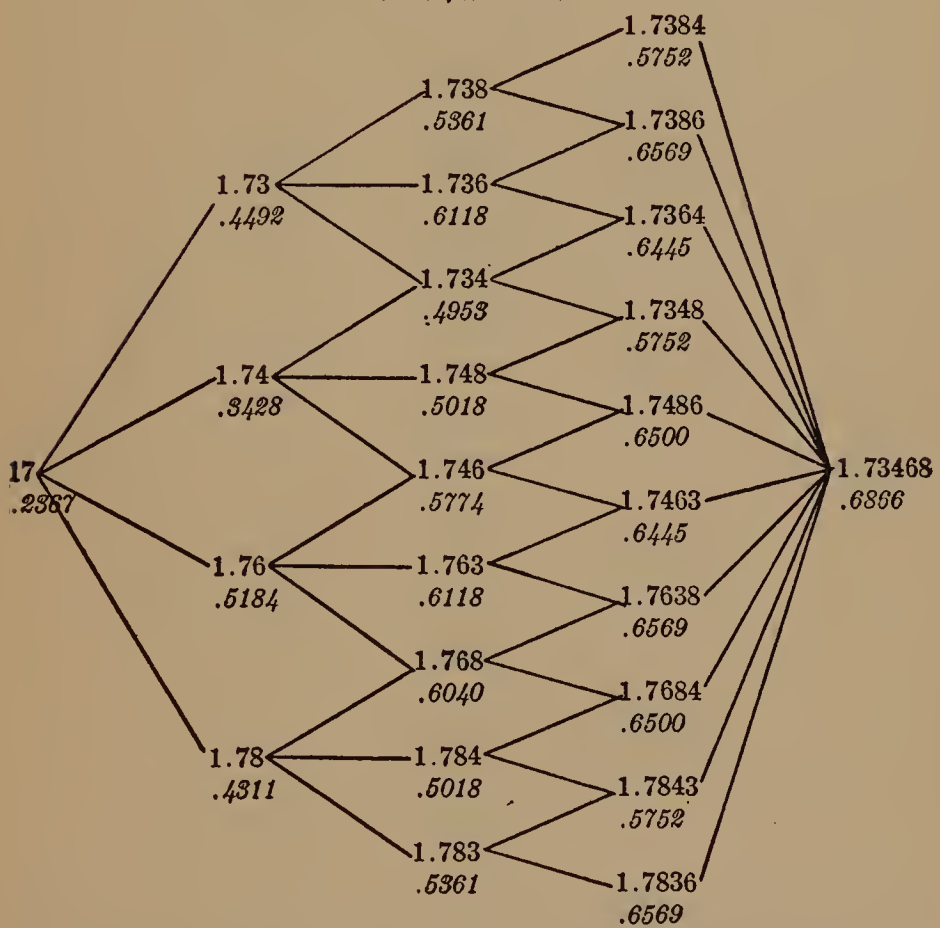
closely related to, or dependent upon, other factors than is any other dimension. This is shown by the fact that in the change from fourth to fifth order multiples it adds of itself least of all to the value of weight prediction. In the second order multiples, shoulder width and height add about the same.

TABLE 15

ALL OF THE MULTIPLE CORRELATIONS (SQUARED) WITH WEIGHT WHEN BIACROMIAL WIDTH IS ONE OF THE FACTORS, IN 815 GIRLS WHOSE MEAN AGE IS 18 YEARS 6 MONTHS.

1—weight
3—width of hips
4—height
6—depth of chest
7—biacromial width
8—width of chest

Volue of R^2 in italic

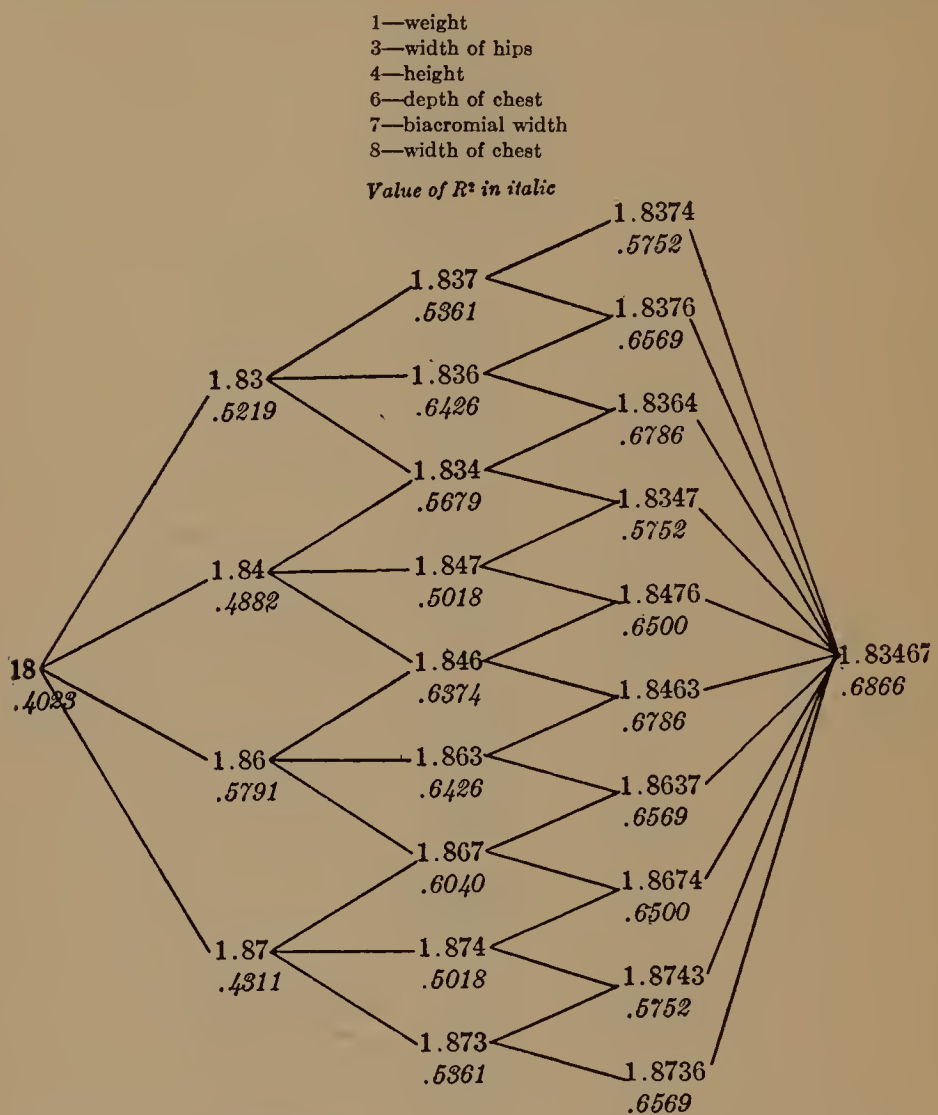


INTERPRETATION OF TABLES SHOWING INCREASE IN R^2

Tables 12, 13, 14, 15, 16 show how much each factor adds to the value of each other factor or combination of factors in predicting weight. Each table begins with the predictive value

TABLE 16

ALL OF THE MULTIPLE CORRELATIONS (SQUARED) WITH WEIGHT WHEN WIDTH OF CHEST IS ONE OF THE FACTORS, IN 815 GIRLS WHOSE MEAN AGE IS 18 YEARS 6 MONTHS.



of one factor and each other factor is added to it, and then in turn each factor is added to each combination of factors, so that there is shown every possible order of increase in combinations. For example, the first of these, Table 12, is built with the hip width predictive value as a basis. Height is first added and the increased value of prediction therefrom is shown.

Then to this combination of hips and height is added chest width and the resulting value shown; then chest depth is added and the again increased resultant value shown; and finally to this combination of hips, height, chest width, and chest depth is added biacromial width, completing the predictive value of the five skeletal measurements.

The remainder of Table 12, and of the other four tables[10] starting with height, chest depth, biacromial width, and chest width, respectively, may be interpreted in a similar manner.

From these tables the reader can see the amount that any dimension adds to any combination. For instance, if he is interested in seeing how much chest depth adds to the combination of height and shoulders, or how much hip width or shoulder width or height, or any other factor adds to any combination of skeletal factors, he need only refer to the code on each table translating the numbers into skeletal dimensions, and then using whichever tables are needed, follow the skeletal dimension in which he is especially interested.

[10] Tables are of squared multiples.

CHAPTER II

THE IMPORTANCE OF WEIGHT RESIDUALS AND COMPARISON OF THE RESULTS OF THIS STUDY WITH SOME OF THE RESULTS OBTAINED ON A YOUNGER GROUP IN THE AMERICAN CHILD HEALTH ASSOCIATION'S SCHOOL HEALTH STUDY

The Weight Residuals

The correlation of weight with all the measurements used in this study produces a low enough multiple to leave a weight residual[1] large enough to be important. Weight residuals in this group of 815 college women would seem to be valuable for diagnostic purposes since the multiple correlation, .83, of weight and the five skeletal measurements is low enough to indicate that other influences than these skeletal measurements doubtless have a large bearing on weight determination.

In comparison with the multiple correlation of weight with these same five skeletal measurements, .95, as found for eleven- and twelve-year-old girls by the American Child Health Association in its *School Health Study*, this multiple, .83, for college women would seem to show that, while in prepubescent girls "the multiples of five skeletal dimensions with weight are high enough to make unimportant the variation amongst children in weight when taken only in relation to skeletal peers,"[2] this assumption does not hold true for the late adolescent group of girls. In other words, if we have certain skeletal measurements for a girl of eleven or twelve years of age, we can determine to within two or three pounds what she will weigh, as weight seems to be almost wholly inherent in bony framework at these ages. But in this group of college women, weight is not so wholly assignable. However, as is stated above, height is cer-

[1] "Weight minus the weight to be expected from the skeletal dimensions as actually measured."—Franzen, Raymond, *op. cit.*

[2] Franzen, Raymond, *op. cit.*

tainly not the best determinant, other measurements being of much greater value at the late adolescent age as well as at the younger ages.

Change in Relative Importance of Factors Between the Periods of Prepubescence and Late Adolescence

Another point seems to be brought out by a comparison of the two groups. The American Child Health Association measurements were made on children before or during the period of acceleration of growth immediately preceding pubescence. It appears, therefore, that while hip width is a very important factor in determining weight at the ages of eleven and twelve years, in the college group at a mean age of eighteen and one-half years, chest depth has taken on more importance, indicating that in the change from prepubescence to late adolescence significant changes in development of the upper trunk take place, as contrasted with the development of hip width in the ages of the younger group.

A comparison of the Beta coefficients (reduced to per cents) on weight of the American Child Health Association groups with those on this group of college girls shows the following:

	11 Year Group	*12 Year Group*	*College Group Mean Age 18½ Yrs.*
Height	14%	15%	16%
Width of hips	33	29	20
Depth of chest	28	26	32
Width of shoulders ..	0	4	9
Width of chest	25	26	23
	100%	100%	100%

Additional comparison of the two groups can be made through direct use of the multiples. By observing the amount that each skeletal dimension adds of itself to the multiple in the two different age groups, we can further support the previous argument that width of hips may be a somewhat more important determinant for weight in the children's group, and that chest depth is decidedly a more significant factor for weight determination in the older group.

For the American Child Health Association data, we have the multiple of all the skeletal factors with weight to four decimals and all of the other multiples to two decimals. In order to make our data comparable, we will set them down to the same number of decimals, four for the multiple of all the skeletal dimensions with weight, and two for the other combinations. Then for the two groups we have:

	11 Year Group	*College Group*
Multiple of all skeletal dimensions with weight	.9441	.8286
Omitting width of hips	.92	.81
Omitting height	.94	.81
Omitting chest depth	.92	.76
Omitting biacromial width	.9441*	.82
Omitting chest width	.93	.80

* This is considered here to be .9441, as in the American Child Health Association data the biacromial width addition is considered to be zero. It is included here necessarily in the comparison, inasmuch as biacromial width does make some contribution, though small, to weight determination in the older group.

For more adequate comparisons, these multiples are squared, giving the following results:

	11 Year Group	*College Group*
Multiple of all the skeletal traits with weight	.8913	.6866
Omitting width of hips	.8464	.6561
Omitting height	.8836	.6561
Omitting chest depth	.8464	.5776
Omitting biacromial width	.8913	.6724
Omitting chest width	.8649	.6400

It will be seen from the foregoing tabulations that the several skeletal factors add, of themselves, to the adequacy of weight prediction in the following comparable amounts:

	11 Year Group	*College Group*
Width of hips adds of itself	.0449	.0305
Height adds of itself	.0077	.0305
Chest depth adds of itself	.0449	.1090
Biacromial width adds of itself	.0000	.0142
Chest width adds of itself	.0264	.0466

Therefore, we see that width of hips adds, of itself, to the multiple a slightly larger amount (.0449) in the children's group

than in the older group (.0305), and that chest depth adds, of itself, to the multiple a significantly greater amount (.1090) in the older group than in the children's group.

Therefore, since width of hips and chest depth add the same to the multiple in the children's group, and this figure (.0449) is the largest amount added by any dimension in this group, and chest depth adds decidedly more to the multiple in the older group, and this figure (.1090) is the greatest amount added by any dimension to the multiple in this group, we may say that the two dimensions of chest depth and width of hips are the most important dimensions as determinants for weight at eleven years, and that chest depth is decidedly a more important factor in the late adolescent age.

Do not these facts, then, seem to indicate: that a heavy prepubescent girl is heavy mainly because of both hip and chest measures; that a heavy late adolescent girl is heavy much more because of chest depth; that the individual differences in chest depth have decidedly more influence on weight in the late adolescent than in the prepubescent group?

CHAPTER III

THE USE OF THE REGRESSION EQUATION IN WEIGHT PREDICTION

Tables may be constructed so as to read weight expectancies from skeletal measurements for the late adolescent group, and since weight residuals are large in this group they may possibly be of more vital importance to health than they are in the prepubescent group.

The multiple regression equation for weight score is:

Expectation in Weight (in kilograms) = 1.137 Width of Hips + .2384 Height + 2.092 Depth of Chest + .407 Biacromial Width + 1.302 Chest Width − 95.1025

In substituting in this equation, all dimensions are to be used in terms of centimeters. Measurements should be recorded to the nearest tenth of a centimeter except height, which is measured to the nearest whole centimeter. For example, if biacromial width is 36.4 cm., it is used as 36.4, and if height is 162.9 cm., it is considered as 163 cm. If an eighteen-year-old girl's measurements are:

Height	163.2 cm.
Biacromial width	34.0 cm.
Chest width	22.2 cm.
Width of hips	26.0 cm.
Chest depth	16.0 cm.,

then the equation for finding her weight expectation would be:

1.137 (26.0) + .2384 (163.0) + 2.092 (16.0) + .407 (34.0) + 1.302 (22.2) − 95.1025

Solving the equation gives 49.5 kilos. This girl actually weighs 49.1 kilos. The height-weight tables give 123 lbs. (55.9 kilos.) as a correct weight for her age and height, indicating that she is 6.8 kilos or 15 lbs. underweight. According to the weight to be expected from her skeletal framework, she should weigh

49.5 kilos; she actually does weigh within one pound of what her skeletal framework seems to promise.[1]

The standard error of estimate for weight is:

$$\text{sigma wt.} \quad \sqrt{1 - r^2_{13}}\ \sqrt{1 - r^2_{14.3}}\ \sqrt{1 - r^2_{16.43}}\ \sqrt{1 - r^2_{17.436}}\ \sqrt{1 - r^2_{18.4367}}$$

$$= 7.22 \times .559912 = 4.043 = 4 \text{ kilos. or } 8.8 \text{ lbs.}$$

This may be said to substantiate the point already stated that although weight predictions from bony framework, considered as a team of five skeletal dimensions, may be of greater value than height alone, yet skeletal framework cannot be held responsible for as much of the individual differences in weight in late adolescence as it is in children of ten, eleven, and twelve years of age. Weight of itself, then, has possibly greater diagnostic value in relation to health in the late adolescent period, and of itself therefore may give more indication of the desirability of some alteration in one's habits of eating, rest, or exercise.

[1] For determining weight expectancy directly in pounds, the following form of the equation may be used:

2.5014 Width of Hips + .5245 Height + 4.6024 Depth of Chest + .8954 Biacromial Width + 2.8644 Chest Width − 209.2255

Using the same skeletal measurements given above, we have:

2.5014 (26.0) + .5245 (163.0) + 4.6024 (16.0) + .8954 (34.0) + 2.8644 (22.2) − 209.2255

Solving gives 108.9 lbs. or 49.5 kilos.

CHAPTER IV

THE SYMMETRY AND ASYMMETRY OF LATE ADOLESCENCE

The Symmetry of Body Build

Body build, normally, has a certain degree of conformity to pattern, which we call symmetry. That is, persons of certain hip width, shoulder width, height, and chest width may be said usually to have a certain "expected" chest depth. We may say that a person probably will be of a certain width in the hips or a certain height if he is of comparable dimensions in his other skeletal framework.

From the skeletal measurements of children, Franzen[1] has developed a method of determining the degree of symmetry or asymmetry of boys and girls of ten, eleven, and twelve years of age. He finds that the skeletal characteristics show relationships that indicate a certain proportion of shared influences, though decidedly not to the same extent for all dimensions, and gives tables and formulæ that can be used to determine the normal expectancy of any one of the five skeletal dimensions from the actual values of the other four, and the degree of symmetry and asymmetry in each dimension for any individual of these ages that is being considered.

We may make similar use of the regression equation and construct symmetry formulæ in our late adolescent group. However, the multiples are not so high as those of the children's groups. There is indication that by the late adolescent age much asymmetry of framework has developed. Assuming equal accuracy of original measures, we may take this to mean that boys and girls of ten, eleven, and twelve years of age tend to follow a pattern rather closely, but as they grow older, at least up to eighteen and one-half years of age,[2] decided divergencies from symmetry develop.

[1] Franzen, Raymond, *op. cit.*

By the use of the regression equation, we may make a prediction of any one skeletal dimension (of the few used in this study) if we have the measures of the other four. This expectancy, then, may be said to be the normal expectancy—within the standard error of estimate—in that dimension for individuals having the same other four measurements.

A girl of the late adolescent age, therefore, for whom we know the measurements of shoulder width, chest width, chest depth, and hip width, may be expected to have a certain height, or if we know her to be of a certain height, chest width, shoulder width, and hip width, we may say that she should have a certain chest depth; and likewise we may determine the normal expectancy of each of the other four skeletal dimensions.

Determination of Expectancy in Each of Five Skeletal Dimensions

The regression equations for determining expectancy in each of the five skeletal dimensions from the other four are:

Expectation of Width of Hips

.044 Height + .229 Chest Depth + .090 Biacromial Width + .298 Chest Width + 5.504

Expectation of Height

.85 Width of Hips + .34 Chest Depth + .55 Biacromial Width + .19 Chest Width + 107.201

Expectation of Chest Depth

− .009 Biacromial Width + .211 Chest Width + .206 Width of Hips + .016 Height + 3.759

Expectation of Biacromial Width

.574 Chest Width + .152 Width of Hips + .051 Height − .020 Chest Depth + 10.103

Expectation of Chest Width

.261 Width of Hips + .009 Height + .210 Chest Depth + .295 Biacromial Width + 1.414

These formulæ may be used in the same way as the equation for determining expectation in weight. In substituting in the

[3] The data used in this study are on a group of late adolescent girls (mean age, eighteen and one-half years). We have no data for a similar age group of boys; therefore, the latter part of this statement is intended to be taken only in reference to girls.

equations, all dimensions are to be used in terms of centimeters. The measurements should be recorded to the nearest tenth of a centimeter except height, which is measured to the nearest whole centimeter.

If a girl has the following measures:

Height	163.1 cm.
Biacromial width	35.8 cm.
Width of hips	26.4 cm.
Depth of chest	17.2 cm.

then the equation for determining the normal expectancy of her chest width is:

$$.261\ (26.4) + .009\ (163) + .210\ (17.2) + .295\ (35.8) + 1.414$$

Solving the equation gives her expectancy in width of chest to be 23.9 cm.

The standard error of estimate of each of the skeletal characteristics is as follows:

$\sigma_{\text{est. width of hips}}$	$1.483 \times .820374 = 1.217$
$\sigma_{\text{est. height}}$	$5.707 \times .913013 = 5.211$
$\sigma_{\text{est. depth of chest}}$	$1.286 \times .896193 = 1.153$
$\sigma_{\text{est. biacromial width}}$	$1.930 \times .821012 = 1.585$
$\sigma_{\text{est. width of chest}}$	$1.483 \times .766593 = 1.137$

Therefore the standard error of estimate of each is:

Width of hips	1.2 cm.
Height	5.2 cm.
Depth of chest	1.2 cm.
Biacromial width	1.6 cm.
Width of chest	1.1 cm.

This study points to the interesting question (worthy of investigation) of the possible use of anthropometric measurements in assessing the fitness of girls of this age for different types of games and sports or for some kinds of physical labor.

CHAPTER V

SUMMARY

1. Height is inadequate as a determinant for weight expectancy in girls of late adolescence. Individual differences in chest and hip measurements are decidedly more significant than height in determining weight expectancy at this age period.

2. Weight residuals from a predicting team of five skeletal dimensions are large enough to be significant in this age group. Weight, therefore, may have some real diagnostic value for indicating degree of health at this age.

3. A comparison of results from the data of this group with results from similar data[1] in children of eleven and twelve years shows that:

a. Since in the older group the multiple of weight and the five skeletal dimensions is decidedly lower than the similar multiple in the younger group, the weight residuals are correspondingly larger; therefore weight may possibly be of greater diagnostic significance in late adolescent than in prepubescent girls.

b. In the determination of individual weight expectancy, in the younger group hip and chest dimensions exert the greatest influence, while in the older group chest depth is decidedly the most significant factor.

4. Employing the regression equation, individual weight expectancy may be determined through the use of five skeletal dimensions, and this amount of weight may be said to be the normal expectancy for a girl of similar bony framework.

5. Symmetry formulæ have been constructed for this late adolescent group, through use of which we may compute for an individual the most probable size, or the normal expectancy.

[1] Data from *School Health Study*, American Child Health Association.

of any one of five skeletal dimensions, when we know the actual measurements of the other four skeletal dimensions. It is suggested that further investigation may lead to the use of anthropometric dimensions in assessing the fitness of girls of this age for games, sports, and physical labor.

APPENDIX

BASIC DATA
BIBLIOGRAPHY

BASIC DATA

TABLE A: GROUP A—25 CASES

INTERCORRELATIONS OF AGE AND SEVEN ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Biac.	Ch. W.	Troch.W.	Ch. D.	Sit. Ht. (t.h.)
Age		−.3177	.0238	−.1539	−.2996	−.0421	−.3902	−.1167
Wt.			.3394	.3716	.5643	.6350	.6901	.4375
Ht.				.3670	.4064	.2694	.0483	.7506
Biac.					.4360	.1148	.1082	.3879
Ch. W. ...						.3034	.5205	.2289
Troch. W.							.3188	.3808
Ch. D. ...								.2010
Mean	296.16	56.80	162.44	35.56	24.14	32.80	17.64	86.96
Sigma	15.87	7.53	6.07	1.48	1.39	3.18	1.29	3.61

Age = Age (in months)
Wt. = Weight (in kilograms)
Ht. = Height (in centimeters)
Biac. = Biacromial Width (in centimeters)
Troch. W. = Width of Hips (in cm.) at great trochanter
Ch. D. = Depth of chest (in centimeters)
Sit. Ht. (t.h.) = Sitting Height (in cm.) to top of head

TABLE B: GROUP B—429 CASES

INTERCORRELATIONS OF AGE AND SEVEN ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Sit. Ht. (7 c.v.)	Biac.	Ch. W.	Iliac	Ch. D.
Age		.0269	−.0597	−.0510	.0761	.0667	.0001	.0922
Wt.			.5513	.3213	.2861	.5470	.6246	.5712
Ht.				.5642	.1269	.3285	.3611	.2467
Sit. Ht. .. (7 c.v.) .					.1229	.1583	.1843	.1443
Biac.						.2523	.3088	.2369
Ch. W. ..							.4845	.2186
Iliac								.3503
Mean	212.02	56.44	163.62	60.79	32.68	24.55	27.54	15.55
Sigma	12.88	7.65	6.10	2.68	2.04	1.59	1.62	1.23

TABLE C

GROUP C—390 CASES

INTERCORRELATIONS OF AGE AND EIGHT ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Sit. Ht. (7 c.v.)	Biac.	Ch. W.	Iliac	Ch. D.	Sit. Ht. (t.h.)
Age		−.0015	−.0382	−.0324	−.0385	−.0470	.0338	.0030	.0443
Wt.			.4491	.3930	.5000	.6428	.6276	.6272	.4283
Ht.				.7357	.3025	.2257	.3416	.1976	.7814
Sit. Ht. (7 c.v.)					.2180	.1888	.2517	.1606	.9086
Biac.						.5462	.4356	.2256	.2898
Ch. W.							.4840	.3604	.2336
Iliac								.3835	.2890
Ch. D.									.2090
Mean	228.40	56.53	163.67	61.51	36.22	24.38	27.11	17.15	85.67
Sigma	11.66	7.16	5.76	2.49	1.83	1.44	1.57	1.23	3.12

TABLE C 2

GROUP C 2—389 CASES

INTERCORRELATIONS OF AGE AND EIGHT ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Sit. Ht. (7 c.v.)	Biac.	Ch. W.	Iliac	Ch. D.	Sit.Ht. (t.h.)
Age		−.0220	−.0373	−.0317	−.0391	−.0763	.0304	−.0012	−.0435
Wt.			.4687	.4087	.5083	.6395	.6192	.6165	.4454
Ht.				.7357	.3034	.2304	.3489	.2047	.7813
Sit. Ht. (7 c.v.)					.2186	.1922	.2569	.1662	.9085
Biac.						.5470	.4366	.2250	.2904
Ch. W.							.4772	.3510	.2375
Iliac								.3702	.2947
Ch. D.									.2149
Mean	228.38	56.45	163.68	61.51	36.22	24.37	27.10	17.14	85.68
Sigma	11.67	6.98	5.76	2.50	1.83	1.44	1.54	1.22	3.12

TABLE D

GROUP D—425 CASES

INTERCORRELATIONS OF AGE AND EIGHT ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Sit. Ht. (7 c.v.)	Biac.	Ch.W.	Iliac	Ch.D.	Sit. Ht. (t.h.)
Age		.0933	.0393	.0437	.0910	.0268	.0765	.0268	.0072
Wt.			.4658	.3159	.4628	.6099	.5830	.6176	.3438
Ht.				.6924	.3171	.3260	.3689	.2195	.7579
Sit. Ht. (7 c.v.)					.2534	.1889	.2613	.0766	.9004
Biac.						.5157	.3353	.1990	.2627
Ch. W.							.4894	.3245	.2427
Iliac.								.3663	.2618
Ch. D.									.0817
Mean	216.48	54.57	162.78	61.03	35.82	23.80	26.84	16.38	85.19
Sigma	10.78	7.16	5.63	2.40	2.00	1.46	1.45	1.23	2.81

TABLE D 2

GROUP D 2—424 CASES

INTERCORRELATIONS OF AGE AND EIGHT ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Sit. Ht. (7 c.v.)	Biac.	Ch.W.	Iliac	Ch.D.	Sit. Ht. (t.h.)
Age		.0860	.0371	.0431	.0877	.0211	.0706	.0171	.0061
Wt.			.4681	.3242	.4548	.5972	.5120	.5844	.3494
Ht.				.6927	.3129	.3208	.3644	.2109	.7577
Sit. Ht. (7 c.v.)					.2348	.1885	.2628	.0748	.9004
Biac.						.5087	.3235	.1784	.2610
Ch. W.							.4741	.2961	.2409
Iliac								.3320	.2607
Ch. D.									.0760
Mean	216.46	54.47	162.76	61.03	35.81	23.79	26.83	16.37	85.19
Sigma	10.78	6.87	5.62	2.40	1.99	1.45	1.42	1.18	2.81

TABLE E

GROUP E—815 CASES

INTERCORRELATIONS OF AGE AND SIX ANTHROPOMETRIC CHARACTERISTICS WITH WEIGHT

	Age	Wt.	Ht.	Biac.	Ch. W.	Iliac	Ch. D.
Age		.0981	.0368	.0754	.1012	.0892	.1519
Wt.			.4626	.4865	.6343	.6111	.6289
Ht.				.3155	.2868	.3450	.2219
Biac.					.5367	.3797	.2317
Ch. W.						.4877	.3778
Iliac							.3788
Mean	222.18	55.51	163.20	36.01	24.08	26.97	16.75
Sigma	12.69	7.22	5.71	1.93	1.48	1.48	1.29

TABLE F

PARTIAL CORRELATIONS BASED ON THE ZERO CORRELATIONS OF TABLE B (429 CASES)

1 = Weight
3 = Width of hips
4 = Height
6 = Depth of chest
7 = Biacromial width
8 = Width of chest

13.8*	=	.4910	13.7	=	.5885
14.8	=	.4700	14.7	=	.5418
16.8	=	.5528	16.7	=	.5408
17.8	=	.1828	18.7	=	.5121
34.8	=	.2444	34.7	=	.3412
36.8	=	.2463	36.7	=	.2999
37.8	=	.2204	38.7	=	.4418
46.8	=	.1898	46.7	=	.2248
47.8	=	.0481	48.7	=	.3089
67.8	=	.1924	68.7	=	.1689
13.6	=	.5522	13.4	=	.5469
14.6	=	.5159	16.4	=	.5383
17.6	=	.1891	17.4	=	.2611
18.6	=	.5270	18.4	=	.4643
34.6	=	.3026	36.4	=	.2890
37.6	=	.2481	37.4	=	.2843
38.6	=	.4463	38.4	=	.4154
47.6	=	.0728	67.4	=	.2139
48.6	=	.2904	68.4	=	.1504
78.6	=	.2115	78.4	=	.2248

* In this and the following tables the subscripts only are given.

TABLE F (*Continued*)

14.3	=	.4474	34.1	=	.0358
16.3	=	.4818	36.1	=	−.1014
17.3	=	.1255	37.1	=	.1739
18.3	=	.3577	38.1	=	.2184
46.3	=	.1376	46.1	=	−.0996
47.3	=	.0174	47.1	=	−.0385
48.3	=	.1882	48.1	=	−.0385
67.3	=	.1445	67.1	=	.0935
68.3	=	.0597	68.1	=	.1365
78.3	=	.1234	78.1	=	.1194
13.78	=	.4700	13.68	=	.4167
14.78	=	.4696	14.68	=	.4462
16.78	=	.5365	17.68	=	.0934
34.78	=	.2400	34.68	=	.2021
36.78	=	.2548	37.68	=	.1758
46.78	=	.1841	47.68	=	.0120
13.48	=	.4394	14.38	=	.4144
16.48	=	.5350	16.38	=	.4939
17.48	=	.1817	17.38	=	.0878
36.48	=	.2520	46.38	=	.1289
37.48	=	.2154	47.38	=	−.0060
67.48	=	.1869	67.38	=	.1384
13.67	=	.5313	13.47	=	.5108
14.67	=	.5127	16.47	=	.5116
18.67	=	.5076	18.47	=	.4312
34.67	=	.2945	36.47	=	.2437
38.67	=	.4159	38.47	=	.3763
48.67	=	.2821	68.47	=	.1074
14.37	=	.4487	13.46	=	.4851
16.37	=	.4723	17.46	=	.1773
18.37	=	.3476	18.46	=	.4602
46.37	=	.1366	37.46	=	.2379
48.37	=	.1876	38.46	=	.3930
68.37	=	.0425	78.46	=	.1995
14.36	=	.4389	16.34	=	.4744
17.36	=	.0645	17.34	=	.1316
18.36	=	.3761	18.34	=	.3113
47.36	=	−.0025	67.34	=	.1435
48.36	=	.1821	68.34	=	.0348
78.36	=	.1163	78.34	=	.1223
13.678	=	.4084	13.478	=	.4169
14.678	=	.4470	16.478	=	.5186
34.678	=	.2032	36.478	=	.2207

TABLE F (*Continued*)

14.378 = .4165	13.468 = .3725
16.378 = .4885	17.468 = .0983
46.378 = .1310	37.468 = .1771
14.368 = .4066	16.348 = .4881
17.368 = .0225	17.348 = .0991
47.368 = −.0244	67.348 = .1403
13.467 = .4635	14.367 = .4406
18.467 = .4407	18.367 = .3720
38.467 = .3630	48.367 = .1836
16.347 = .4643	17.346 = .0729
18.347 = .3001	18.346 = .3353
68.347 = .0175	78.346 = .1187

13.4678 = .3626
14.3678 = .4074
16.3478 = .4813
17.3468 = .0354
18.3467 = .3299

TABLE G

MULTIPLE *R*'S AND R^2'S IN ORDER OF SIZE BASED ON TABLES B AND F (429 CASES)

1 = Weight
3 = Width of hips
4 = Height
6 = Depth of chest
7 = Biacromial width
8 = Width of chest

	R	R^2
17	.2861	.0819
18	.5470	.2992
14	.5513	.3039
1.78	.5680	.3226
16	.5712	.3263
1.47	.5917	.3501
1.67	.5919	.3503
13	.6246	.3901
1.37	.6336	.4014
1.48	.6738	.4540
1.38	.6842	.4681
1.478	.6871	.4721
1.378	.6872	.4722
1.46	.7111	.5057
1.34	.7156	.5121
1.68	.7165	.5134
1.678	.7194	.5175
1.347	.7215	.5206
1.467	.7219	.5211
1.36	.7293	.5319

TABLE G (*Continued*)

1.367	.7306	.5338
1.348	.7479	.5594
1.3478	.7508	.5637
1.368	.7733	.5980
1.3678	.7733	.5980
1.468	.7811	.6111
1.4678	.7836	.6140
1.346	.7886	.6219
1.3467	.7899	.6239
1.3468	.8150	.6642
1.34678	.8153	.6647

TABLE H

PARTIAL CORRELATIONS BASED ON THE ZERO CORRELATIONS OF TABLE E (815 CASES)

1 = Weight
3 = Width of hips
4 = Height
6 = Depth of chest
7 = Biacromial width
8 = Width of chest

13.8	=	.4472	13.7	=	.5276
14.8	=	.3790	14.7	=	.3728
16.8	=	.5439	16.7	=	.6074
17.8	=	.2240	18.7	=	.5062
34.8	=	.2452	34.7	=	.2565
36.8	=	.2406	36.7	=	.3231
37.8	=	.1602	38.7	=	.3637
46.8	=	.1280	46.7	=	.1612
47.8	=	.1999	48.7	=	.1468
67.8	=	.0370	68.7	=	.3087
13.6	=	.5182	13.4	=	.5426
14.6	=	.4261	16.4	=	.6087
17.6	=	.4506	17.4	=	.4047
18.6	=	.5511	18.4	=	.5906
34.6	=	.2891	36.4	=	.3302
37.6	=	.3242	37.4	=	.3042
38.6	=	.4022	38.4	=	.4324
47.6	=	.2784	67.4	=	.1748
48.6	=	.2249	68.4	=	.3364
78.6	=	.4987	78.4	=	.4908
14.3	=	.3389	34.1	=	.0888
16.3	=	.5425	36.1	=	−.0089
17.3	=	.3474	37.1	=	.1192
18.3	=	.4867	38.1	=	.1636
46.3	=	.1050	46.1	=	−.1001
47.3	=	.2125	47.1	=	.1167
48.3	=	.1446	48.1	=	−.0096
67.3	=	.1027	67.1	=	−.1094
68.3	=	.2390	68.1	=	−.0351
78.3	=	.4352	78.1	=	.3377

TABLE H (*Continued*)

13.78 = .4275	13.68 = .3883
14.78 = .3500	14.68 = .3718
16.78 = .5499	17.68 = .2432
34.78 = .2204	34.68 = .2227
36.78 = .2379	37.68 = .1560
46.78 = .1232	47.68 = .1970
13.48 = .3949	14.38 = .3106
16.48 = .5398	16.38 = .5024
17.48 = .1634	17.38 = .1724
36.48 = .2176	46.38 = .0733
37.48 = .1171	47.38 = .1679
67.48 = .0117	67.38 = −.0015
13.67 = .4407	13.47 = .4817
14.67 = .3506	16.47 = .5976
18.67 = .4218	18.47 = .4919
34.67 = .2188	36.47 = .2954
38.67 = .2933	38.47 = .3410
48.67 = .1033	68.47 = .2919
14.37 = .2893	13.46 = .4561
16.37 = .5435	17.46 = .3821
18.37 = .3972	18.46 = .5165
46.37 = .0856	37.46 = .2650
48.37 = .0594	38.46 = .3615
68.37 = .2169	78.46 = .4660
14.36 = .3375	16.34 = .5417
17.36 = .3493	17.34 = .2994
18.36 = .4377	18.34 = .4700
47.36 = .2040	67.34 = .0827
48.36 = .1239	68.34 = .2275
78.36 = .4252	78.34 = .4183
13.678 = .3657	13.478 = .3835
14.678 = .3406	16.478 = .5452
34.678 = .1983	36.478 = .2177
14.378 = .2901	13.468 = .3376
16.378 = .5103	17.468 = .1868
46.378 = .0747	37.468 = .1173
14.368 = .3176	16.348 = .5059
17.368 = .2004	17.348 = .1282
47.368 = .1684	67.348 = −.0141
13.467 = .3983	14.367 = .2902
18.467 = .4139	18.367 = .3408
38.467 = .2789	48.367 = .0419

TABLE H (*Continued*)

16.347 = .5438	17.346 = .3044
18.347 = .3977	18.346 = .4237
68.347 = .2129	78.346 = .4118

13.4678 = .3236
14.3678 = .2938
16.3478 = .5120
17.3468 = .1574
18.3467 = .3438

TABLE I

MULTIPLE R'S AND R^2'S IN ORDER OF SIZE BASED ON TABLES E AND H (815 CASES)

1 = Weight
3 = Width of hips
4 = Height
6 = Depth of chest
7 = Biacromial width
8 = Width of chest

	R	R^2
14	.4626	.2140
17	.4865	.2367
1.47	.5855	.3428
13	.6111	.3734
16	.6289	.3955
18	.6343	.4023
1.78	.6566	.4311
1.34	.6674	.4454
1.37	.6702	.4491
1.48	.6987	.4882
1.347	.7038	.4953
1.478	.7084	.5018
1.46	.7108	.5052
1.67	.7200	.5184
1.38	.7224	.5219
1.378	.7322	.5361
1.36	.7468	.5578
1.348	.7536	.5679
1.3478	.7584	.5752
1.467	.7599	.5574
1.68	.7610	.5791
1.678	.7772	.6040
1.346	.7798	.6081
1.367	.7822	.6118
1.468	.7983	.6373
1.368	.8016	.6426
1.3467	.8028	.6445
1.4678	.8062	.6500
1.3678	.8105	.6569
1.3468	.8238	.6786
1.34678	.8286	.6866

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